LNG as a marine fuel

Safety and Operational Guidelines – Bunkering

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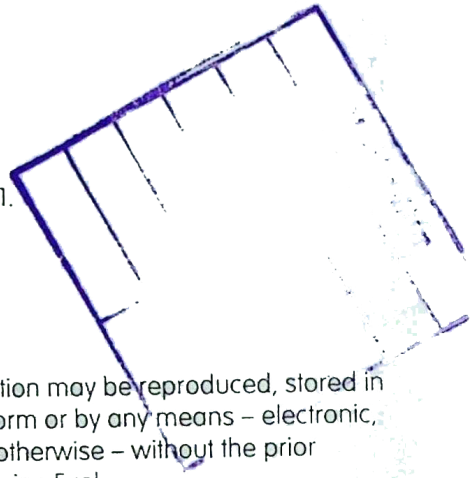

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The Society for Gas as a Marine Fuel

The Society for Gas as a Marine Fuel (SGMF) is a non-governmental organisation (NGO) established to promote safety and good practice in the use of natural gas as a marine fuel. The society supports the wider use of gas as marine fuel by developing technical guidelines that encourage safe and responsible operations. More information on the society is available at: https://sgmf.info

Disclaimer

The advice given in these guidelines is based upon good, if not the best, current industry practice and relevant information. It is intended solely for guidance and use at the owner's/operator's own risk. No responsibility is accepted by SGMF – nor by any person, company or organisation related to SGMF – for any consequences resulting directly or indirectly from compliance with, or adoption of, any of the recommendations or guidance.

Notes:

1. This document provides only recommendations. They are not intended to constitute a detailed technical specification or operational procedure and apply only to the bunkering of liquefied natural gas (LNG) to a gas-fuelled vessel. It is the responsibility of the owner/operator:
   a. to develop appropriate operational guidance for a specific gas-fuelled vessel, bunkering facility and their equipment and systems, based on the builder's and manufacturer's instructions and these recommendations

b. to ensure that any design specification meets the actual operational conditions to which the whole bunkering operation will be subjected over the asset lifetime

2. The recommendations and considerations in the ***Lessons Learned*** sections represent the collective experience of SGMF's membership on common issues and challenges that may arise during LNG bunkering operations:
   a. they are not intended to constitute a technical specification or to provide specific safety recommendations
   b. their application is left to the skilled design team and operator, who should evaluate which are applicable or not to their asset and bunkering supply scenario and, if so, under which circumstances

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Reader Key

Clarifications and qualifications

Codes/standards references

Case studies/examples/ lessons learned

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Foreword

LNG has established itself as the "marine fuel of the future, available today" – supporting the transition to a cleaner, less carbon-intensive shipping industry.

LNG provides significant benefits in reducing harmful local air emissions to negligible levels and cutting carbon dioxide (CO_2) emissions by a fifth. CO_2 reductions can be improved substantially if bio-LNG or, in future, synthetic LNG is used.

As a result of these benefits, the LNG-fuelled fleet has grown dramatically. With the entry into service of larger ships, as well as the growth in the number of ships in service and on order, LNG bunkering operations are growing – and will continue to do so.

As the quantity of LNG being supplied and the number of bunkering operations increases, safety remains paramount. Identifying risk and maintaining our focus on safety in gas bunkering operations will be vital.

An ambition to translate the successful safety record of seaborne LNG trades into success in LNG bunkering has been realised; to date, the safety record of LNG bunkering operations has been exceptional.

Much of that success is attributable to the guidelines, work and influence of the Society for Gas as a Marine Fuel (SGMF) – building on experience gained in the carriage of LNG. Adherence to such guidance, as well as mandatory port and ship regulatory requirements, combined with growing awareness, will underpin future success.

As we look further ahead, this "safety first" approach, built on accumulated experience and the continued application of expertise, will need to be embraced with further innovation and the development of new fuels – such as ammonia and hydrogen – for use as marine bunkers.

Accordingly, I strongly encourage and advocate our continued focus on safe bunkering and our support for the important work and leadership of the SGMF.

Martial Claudepierre
Bureau Veritas
General Manager Sustainable Shipping and Working Group Chairman

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Abbreviations

The following abbreviations are used throughout this document:

BF – Bunkering Facility

BOG – Boil-Off Gas

LNGBMP – LNG Bunker Management Plan

BSL – Bunkering Safety Link

DD/CC – Dry-Disconnect/Connect Coupling

EMSA – European Maritime Safety Agency

ERC – Emergency Release Coupler

ERS – Emergency Release System

ESD – Emergency shutdown

GFV – Gas-Fuelled Vessel

HAZOP – HAZard and OPerability study

HAZID – HAZard Identification

IACS – International Association of Classification Societies

IAPH – International Association of Ports and Harbours

IGF – International Code of Safety for Ships using Gases or other Low-flashpoint Fuels

IGC – International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

JBP – Joint Bunkering Plan

LFL – Lower Flammable Limit

LNG – Liquefied Natural Gas

LBV – LNG Bunker Vessel

PIC – Person-In-Charge

POAC – Person-in-Overall-Advisory-Control

PPE – Personal Protective Equipment

P&ID – Piping and Instrumentation Diagram

PRV – Pressure-Relief Valve

QCA – Quantitative Consequence Assessment

QualRA – Qualitative Risk Assessment

QRA – Quantitative Risk Assessment

QC/DC – Quick Connect/ Disconnect Coupler

SMS – Safety Management System

SIGTTO – Society of International Gas Tanker and Terminal Operators

STCW – International Convention on Standards of Training, Certification and Watchkeeping

TGN – Technical Guidance Note

Definitions

ALARP/ALARA
As Low As Reasonably Practicable/ As Low As Reasonably Achievable, without incurring excessive cost.

Boil-off Gas (BOG)
The vapour created when liquefied gas evaporates.

Bunker Management Plan (LNGBMP)
A collection of documents relevant to LNG bunkering activities, including safety procedures. Used to communicate information between the supplier and receiver. It may also be shared with other stakeholders such as port authorities and terminal operators.

Bunker station
The location(s) on board a vessel from which fuels are loaded and discharged to a bunkering facility.

Bunkering facility
Any technology or system designed to be used to transfer/bunker liquefied gas as fuel to a gas-fuelled vessel. It usually consists of a bunker vessel, road tanker or terminal.

Bunkering Safety Link (BSL)
Connects the supplier's and receiver's emergency shutdown (ESD) systems. It may be pneumatic, electric, fibre-optic or wireless. Also referred to as the "ESD link" or "Ship-to-Shore Link" (SSL).

Competent Authority
In this document, the general term "competent authority" describes an organisation with jurisdiction over the location, operation and/ or assets involved. The competent authority can have a legal, operational and location-specific interest over the operation and related activities, and can have a statutory function and enforce requirements, rules and standards. Different organisations, or more than one organisation, may act as a competent authority, depending on the activity being undertaken.

Connection flange
The part of the bunkering transfer system that connects to the gas-fuelled vessel's manifold. It can be a flange or a dry-disconnect/ connect coupling nozzle.

Coupling nozzle
The half part of the dry-disconnect/ connect coupling, bolted to the bunkering transfer system, which permits quick connection and disconnection to the receptacle installed on the gas-fuelled vessel's manifold. It includes an internal valve to seal the nozzle/transfer system when disconnected.

Coupling receptacle
The half part of the dry-disconnect/ connect coupling bolted to the gas-fuelled vessel's manifold to

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Definitions

which the nozzle installed on the bunkering transfer system will be connected. It includes an internal valve to seal the receptacle/ manifold when disconnected.

Dry-Disconnect/Connect Coupling (DD/CC)
A manually-operated mechanical device enabling quick and safe connection and disconnection of the hose bunkering system to the manifold of the receiving vessel without employing bolts. The coupling consists of a nozzle and a receptacle. These couplings are also known as "Dry-Disconnect Couplings" or "Dry-Break Couplings". All DD/CCs are a type of Quick Connect Disconnect Coupler (QC/DC). Not all QC/DCs are DD/CCs but all DD/CCs are QC/DCs.

Emergency Release Coupler (ERC)
A coupling installed on liquid and vapour lines, as a component of the Emergency Release System (ERS), enabling quick physical disconnection of the transfer system from the unit to which it is connected. It is designed to prevent leakage and damage to loading/ unloading equipment if the transfer system's operational envelope and/or parameters are exceeded.
An active controlled ERC is an emergency release coupler whose activation can be manually or automatically triggered by a control system and associated control switch/ signal.
A passive ERC is an emergency release coupler, triggered only by a set "breakaway" load to the ERC itself. Typically, a mechanical tension applied at the ERC collar when the gas-fuelled vessel and bunkering facility drift away from each other.

Emergency Release System (ERS)
A system that provides safe bunkering shutdown, transfer system isolation and quick release of hoses or transfer arms between the supplier and receiver to minimise product release at disconnection time.

Emergency Shutdown (ESD) (Bunkering)
The bunkering emergency shutdown is the event, signal or process initiated in an emergency to shut down the bunkering operation.
The process is divided into two consecutive stages: ESD 1 and ESD-2.
The first stage, ESD-1, is intended to stop the flow in a controlled manner. The initiation of an ESD-1 process does not imply that an ESD-2 process will be initiated soon after. The second stage ESD-2 process is primarily intended to protect the bunkering transfer system,

equipment and ship's manifold should the vessel drift out of a predetermined operating envelope The ESD-2 release is usually initiated by the bunkering facility either automatically or manually.

ESD-1
The first stage of the bunkering emergency shutdown process (see Emergency shutdown).

ESD-2
The second stage of the bunkering emergency shutdown process (see Emergency shutdown).

ESD manifold valve
A remotely operated shutdown valve near the presentation flange closed in bunkering emergency shutdown by the bunkering ESD system.

ESD system (bunkering)
An ESD system safely and effectively ends the bunkering operation/process by stopping the transfer of LNG and vapour between the supplier and receiver. A bunkering ESD system should be found on board the gas-fuelled vessel and at the bunkering facility.

Flash gas
This refers to vapour spontaneously produced when liquefied gas is subjected to boiling from heating or depressurisation.

Fuel
In the context of the recommendations in this document, "fuel" means natural gas in its liquid or gaseous state.

Gas-Fuelled Vessel (GFV)
An IGF-compliant vessel using gas as marine fuel.

HAZard and OPerability study (HAZOP)
A HAZard and OPerability study is a qualitative technique based on guide-words which provides a detailed, systematic, examination – by a group of multidisciplinary specialists – of components within a system to determine what would happen if a particular component were to fail or operate outside its normal design mode.

HAZard IDentification (HAZID)
A HAZard Identification study is the process of identifying hazards – performed by a group of specialists in a systematic way – to plan for, avoid, or mitigate their impacts. Many specific methods are available.

Hazardous area/zone
The three-dimensional space in which a combustible or explosive atmosphere can be expected to be present frequently enough to require special precautions for the control of potential ignition sources.

Definitions

Defined by national regulations and both the IGF and IGC Codes.

Hose Bunker System
A hose bunker system allows the transfer of liquefied gas between a bunkering facility and a gas-fuelled vessel primarily using a flexible hose to transfer liquid and/or vapour.

Linked ESD System (bunkering)
The combined and connected arrangement of the bunkering facility's ESD system, the gas-fuelled vessel's ESD system, and the Bunkering Safety Link (BSL).

Liquid
In this document, liquid is fuel (natural gas) in the liquid phase.

LNG bunkering
The process of re-fuelling an LNG powered vessel from a bunkering facility.

LNG Bunkering Organisation
The organisation that staffs and operates a bunkering facility

Manifold flange
The flange permanently located on the gas-fuelled vessel's manifold, to which the reducer or spool piece should be connected.

Mobile-to-ship/truck-to-ship
An LNG bunkering operation to a gas-fuelled vessel from a mobile bunkering facility. Mobile bunkering facilities can consist of a truck, rail car or other mobile device (including portable tanks) used to bunker LNG.

Person-In-Charge (PIC)
The individual responsible for managing the bunkering operation on behalf of either the bunkering facility or the gas-fuelled vessel. One PIC might act as the Person-in-Overall-Advisory-Control (POAC).

Person-in-Overall-Advisory-Control (POAC)
An individual who manages the overall bunkering operation and coordinates the work of the supplier and receiver PICs. It may be performed by one of the PICs or a separate individual.

Presentation Flange
The part of the gas-fuelled vessel's manifold to which the transfer system is connected. Typically a spool-piece flange or a dry-disconnect/connect coupling receptacle.

Quick Connect Disconnect Coupler (QC/DC)
A Quick Connect/Disconnect Coupler (QC/DC) is a generic description of couplers. It uses a manual or hydraulic mechanical device to connect the transfer

system (such as a loading arm) to the bunkering manifold presentation flange without employing bolts.

Receiver
In this document, receiver is a general term used to refer to one or more organisations with ownership, operational and/or legal interests in a gas-fuelled vessel. The receiver may be the vessel owner(s), the charterer or the operator.

Receiving ship operator
The organisation staffing and operating a gas-fuelled vessel.

Reducer/spool piece
A short section of pipe bolted outboard of the manifold flange.

Ship-to-ship
A bunkering operation to a gas-fuelled vessel from a floating storage or bunker vessel.

Shore-to-ship
A bunkering operation to a gas-fuelled vessel from a fixed bunkering facility or terminal.

SIMultaneous Operations (SIMOPs)
Defined in this document as "bunkering plus one or more other independent operations conducted together within the control of the PIC(s), where the operations may impact, or increase impacts, on personnel safety, ship integrity and/or the environment".

Supplier
Supplier relates to the fuel owner or organisations mandated by them in the operation or development of a bunkering activity.

Transfer system/bunkering transfer system
A loading arm made of articulated piping or a transfer hose solution, or a combination of articulated piping and hose, that enables the transfer of liquefied gas from a bunkering facility to a gas-fuelled vessel.

Truck-to-ship
(See mobile-to-ship)

Vapour
The gaseous phase of liquefied gas.

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1. Purpose and Scope

1.1 Aims and Objectives

Safety and Operational Guidelines – Bunkering provides guidance to all the stakeholders involved in the bunkering of ships with liquefied natural gas (LNG):

- shipowners and operators
- suppliers of LNG as a marine fuel
- maritime administrations
- port authorities and terminal operators
- local and national authorities

A range of potential hazards are associated with bunkering liquefied natural gas (LNG). Experience of LNG bunkering to date, and of the wider LNG marine transport industry, shows that when good practice is applied and followed, risks can be effectively mitigated.

The overall aim of these guidelines is therefore to ensure that gas-fuelled ships are bunkered safely, reliably, efficiently and in an environmentally responsible way, with any fugitive emissions of natural gas effectively controlled.

It is assumed that receiving ships and LNG supply facilities comply with applicable codes, regulations and guidelines.

1.2 Applicability

These guidelines and recommendations apply to:

- LNG bunkering supply scenarios, as described in Section 3.1.1
- any gas-fuelled vessel compliant with the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (the IGF Code)
- any bunkering facility – for instance, a bunker vessel, a terminal, or a mobile truck, rail car or other mobile device (including portable tanks) – used to bunker LNG

Gas-fuelled vessels that are not formally required to comply with the IGF Code – for example, inland waterway and IGC vessels – may also benefit from the guidance in this publication, as this will ensure a common and consistent approach across the industry.

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Currently, this publication addresses the specific requirements for Liquefied Natural Gas (LNG) used as a marine fuel as well as synthetic and bio-LNG. Its content may also, with appropriate limitations, be used as a reference for other low-flashpoint fuels and systems not specifically addressed in these guidelines.

1.3 New to the Latest Edition

New additions in v3.0 of the SGMF bunkering guidelines include the sharing of ***Lessons Learned***. These are based on the collective experience of SGMF's members and hundreds of successfully conducted bunkering operations. The aim is to provide the reader with an insight into how common challenges have been overcome by the industry, providing invaluable guidance to newcomers.

1.4 Structure

While this is an extensive publication, for the benefit of readers it is broken down into different sections to support the planning, development and implementation of the bunkering operation, starting from the essential knowledge in Chapter 3 to the various risk assessment techniques for identifying hazards and mitigations in Chapter 9.

To facilitate a common approach across the industry, the bunkering operation has been divided into four main stages (see Section 3.4): Design, Planning, Preparation and Operations (covered in detail in Chapters 4 to 7).

At each stage, key considerations are defined, and guidance is provided, including an examination of the roles and responsibilities of each key stakeholder. Additional special considerations and operations for bunkering operations are provided in Chapter 8.

Chapter 10 provides a list of relevant publications.

1.5 What is not Covered

These guidelines do not consider:

- commercial or contractual aspects of the bunker transfer between the two parties
- bunker delivery notes (BDNs), or
- the measurement of quantity or quality of LNG

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2. Introduction

2.1 The Importance of Effective Management

The inherent properties of LNG, especially its cryogenic nature and behaviour, differ significantly from conventional marine fuels. They present safety hazards and create risks that must be understood and mitigated during bunkering operations.

This guide recommends a risk management framework for LNG bunkering, in which attention must be paid to:

- the safe handling of LNG and its vapour
- the control of all potential sources of ignition, and
- curbing fugitive emissions to the atmosphere – especially the discharge of gas before, during or after bunkering

Throughout the LNG bunkering chain, each element must be carefully designed and constructed. Appropriate safety, operational and maintenance procedures should be in place to be carried out by competent personnel.

The owners and operators of gas-fuelled vessels and bunkering facilities should consider that, while most LNG bunkering operations will fall into the types of bunkering supply scenarios defined in the publication, each operation will have unique characteristics and challenges with specific risks that have to be assessed and managed.

Specific LNG bunkering operational procedures should be developed for each bunkering supply scenario, based on the recommendations of this document, builder's/manufacturer's instructions and the owner's operational philosophies.

Because LNG bunkering is a growing industry, SGMF strongly recommends that incidents and lessons learned are reported and shared so that future editions of this document can capture and incorporate industry experience.

2.2 Reader's Guide

While SGMF recommends that readers should read this publication in its entirety, the four reading paths set out below are a simple guide through the different chapters. The aim is to help readers with different priorities

focus on the most relevant sections for them, taking into account roles, responsibilities, and the stage of development of the bunkering operation.

Recommendations:

1. Chapters marked as **Essential reading** should be read in their entirety and fully understood. This includes any other publications referred to in these chapters.
2. Chapters marked as **Information** provide additional or more in-depth information which may be read to support the knowledge learned in the essential reading chapters.
3. Each chapter includes **Lessons Learned.** These sections contain additional information and knowledge based on collected industry experience. They may be read to complement knowledge learned in the essential reading chapters.

2.2.1 Reading Paths

1. Design
This path is for those considering the design, development and construction of the gas-fuelled vessel and the bunkering facility (bunker vessel, terminal, mobile installation and so on).

3. Planning
The Planning path is for those considering the bunkering location, operation planning and licensing to bunker.

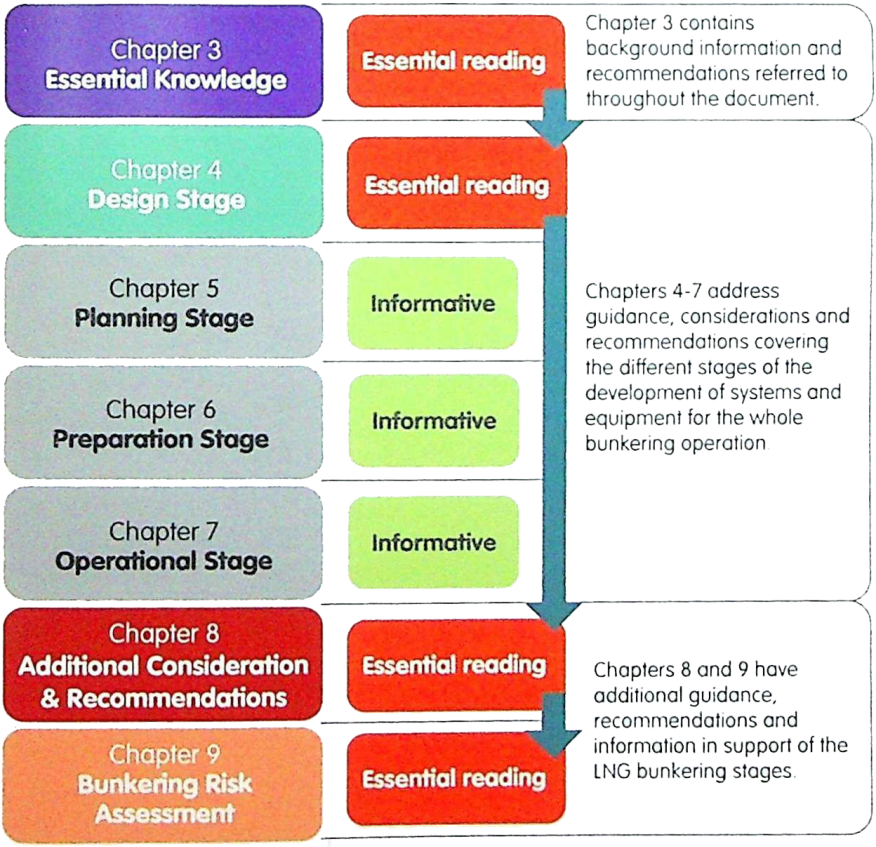
3. Operations
This path is for those preparing for bunkering operations.

4. General Knowledge
This is for anyone seeking general and basic knowledge of LNG bunkering.

These four paths through the guide are represented graphically below, using the chapter colour coding from the Contents page.

2.2.2 Reading Path 1. Design

Principal readers	• Gas-fuelled vessel owners • Bunkering facility owners • Designers
Description	Guidance and recommendations to consider in the early stages of the design of a new gas-fuelled vessel or bunkering facility and during operations.
When to consult	In the months or year(s) before the first bunkering operation and when a gas-fuelled vessel or bunkering facility is being designed



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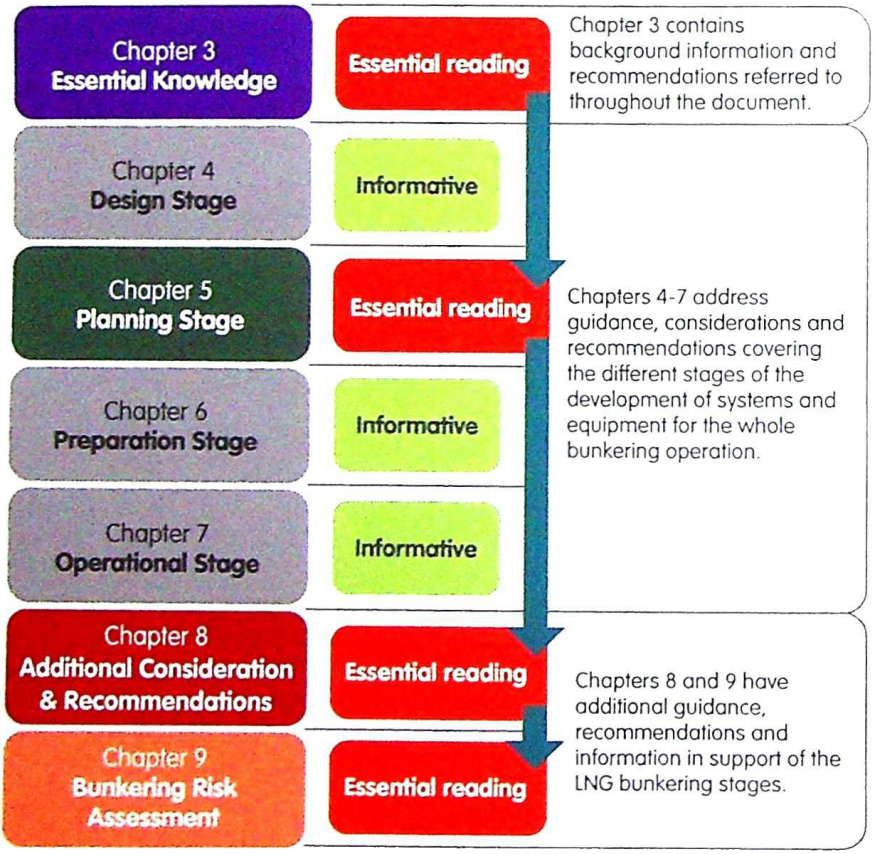
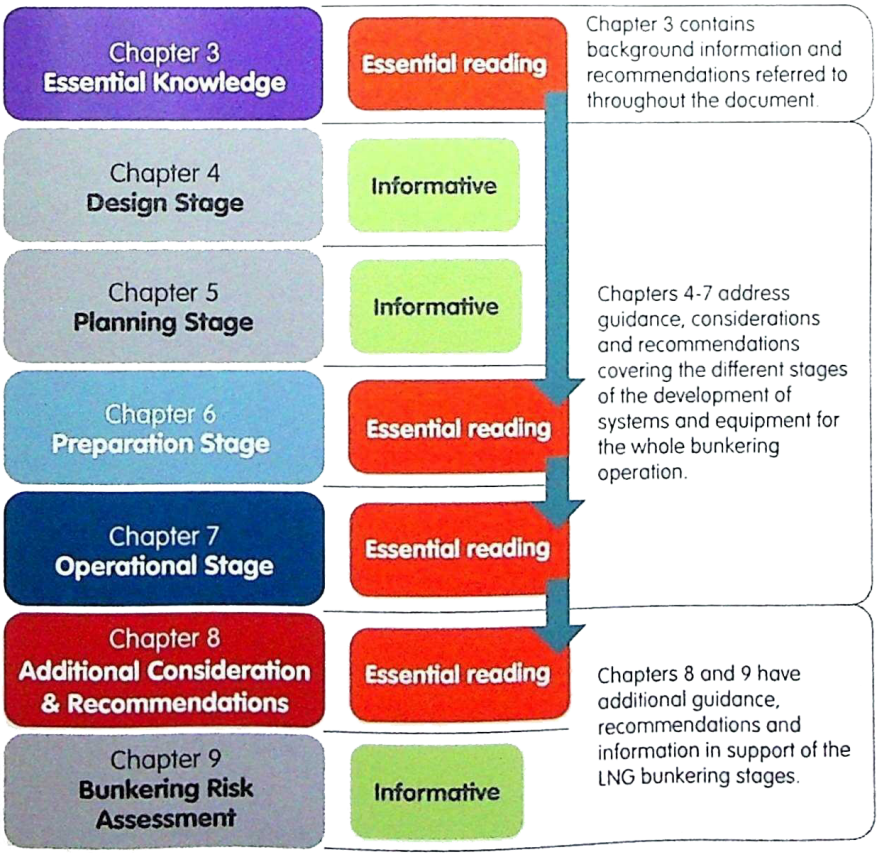
2.2.3 Reading Path 2. Planning

Principal readers	• Gas-fuelled vessel owners • Bunkering facility owners • Port authorities • Regulators
Description	Guidance and recommendations to consider during bunker operations and location planning, including permitting and licensing.
When to consult	For activities typically undertaken 2-12 months before the first or a new bunkering operation.



2.2.4 Reading Path 3. Operations

Principal readers	• LNG bunkering organisations • Receiving ship operators • Persons-in-Charge (PICs) • Gas-fuelled vessel owners • Bunkering facility owners
Description	Guidance and recommendations addressing the required operational and safety steps of the bunkering equipment and systems during preparation and bunkering.
When to consult	For activities to prepare for a bunkering operation, typically undertaken 2-48 hours before it is due to start, as well as activities carried out during the LNG bunker up to its completion.



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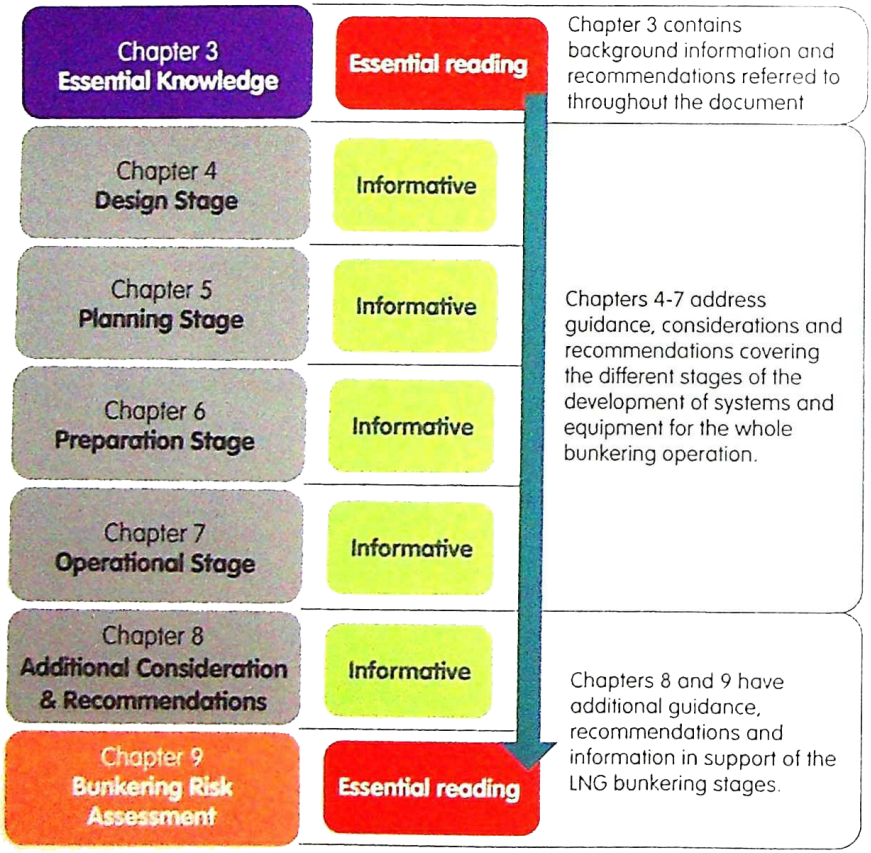
2.2.5 Reading Path 4. General Knowledge

Principal readers	• Operators of terminals where bunkering takes place • Emergency services • Port users • Neighbouring facilities • The general public
Description	General and basic knowledge about LNG bunkering. This is the minimum recommended reading for stakeholders that have an interest in the operation but are not directly involved.
When to consult	At any time.



3. LNG Bunkering – Essential Knowledge

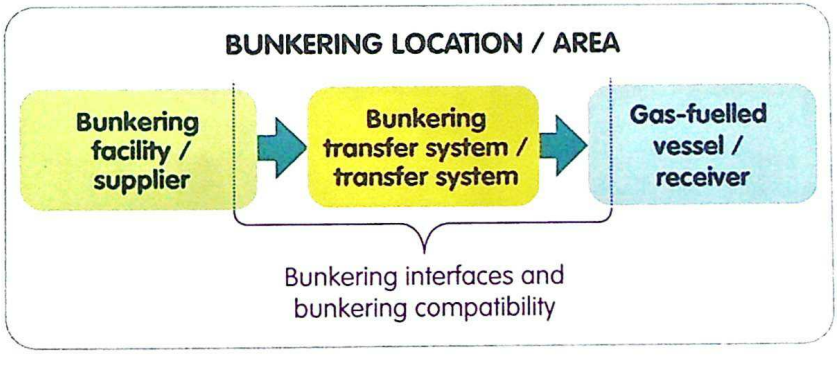
This chapter provides readers with basic background knowledge and an understanding of the different LNG bunkering supply scenarios, and the systems and equipment employed. It also identifies the main stakeholders involved in bunkering operations.

The objective is to facilitate a common approach to LNG bunkering and map out a path through the different guidance, requirements, rules, codes and good practices that are currently available.

3.1 LNG Bunkering Supply Scenarios

LNG can be supplied to a gas-fuelled vessel in various ways. The type of bunkering facility defines the type of bunkering supply scenario, as discussed in Section 3.1.1. However, key elements that are found in all scenarios are defined below (see Figure 3.1):

Figure 3.1: Bunkering Supply Scenario - General Layout



Bunkering facility (BF)
The bunkering facility may consist of a floating, shore-based, fixed, or mobile fuel-supply facility, such as a bunker vessel, road tanker or terminal. It is defined as any technology or system designed to be used to transfer/bunker liquefied gas as fuel to a gas-fuelled vessel.

Bunkering transfer system/transfer system

Note:
For the purposes of this document, the owner and operator of the bunkering facility owns the bunkering transfer system although in some circumstances, the "receiver" – the owner and operator of the gas-fuelled vessel – may also own the bunkering transfer system.

A transfer hose solution or a loading arm made of articulated piping – or a combination of the two – allows the transfer of liquefied gas between a fuel supplier and a gas-fuelled vessel.

It comprises all the equipment between the bunkering manifold flanges of the bunkering facility and the receiving gas-fuelled vessel. This includes: transfer arms and/or hoses; the Emergency Release System (ERS); electrical insulation flanges; dry-disconnect/connect couplings (DD/CCs); and the Bunkering Safety Link (BSL) used to connect the supplying and receiving emergency shutdown (ESD) systems.

Gas-fuelled vessel (GFV)
For the purposes of this document, a gas-fuelled vessel is defined as an IGF-compliant vessel using LNG as marine fuel.

Note:
It is assumed in this document that the receiving vessel has been built in compliance with the requirements of the IGF Code, which sets a common and standard threshold on vessel and equipment design and safety.

Vessels not compliant with the IGF Code but using LNG as fuel may use these guidelines as a reference, aiming to preserve or enhance the minimum threshold safety principles laid out in them.

Bunkering location/area
The location or area where the bunkering operation occurs can, for example, be in open water or alongside a berth in a port or terminal.

Knowledge of the bunkering area and location informs the parties involved about:

- the environmental and surrounding conditions during which the

operation will be conducted
- what local and national regulations might apply
- which local authorities/parties may have jurisdiction over the operations – for example, port authorities, coast guards, terminal operators, health, safety and environment (HSE) officials and so on
- what other operations outside bunkering might need to be considered as part of a SIMOPs assessment (see Section 5.7)

Bunkering interfaces and compatibility

In any bunkering supply scenario, the bunkering interfaces – of which the bunkering transfer system is a main part – are a key factor in determining compatibility between supplier and receiver (see Section 3.7).

Note:

A lack of proper understanding of what needs to be done to ensure compatibility between a receiving gas-fuelled vessel and a supplying bunkering facility is currently one of the main barriers to responsible and efficient LNG bunkering operations.

While these guidelines do not specifically address how to assess compatibility between a bunkering facility and a gas-fuelled vessel, a number of recommendations are provided to ensure the compatibility challenge is properly considered from the early stages of the design of the systems and bunkering operation, through operational procedures, testing and checking.

3.1.1 Typical ship bunkering supply scenarios

Most bunkering supply scenarios fall into one of three categories.

Ship to Ship
by an LNG bunker vessel, barge or floating installation

Shore to Ship
by a fixed installation or terminal

Mobile to Ship
by truck or by portable LNG tanks

Each scenario has advantages and disadvantages and should be evaluated for each gas-fuelled vessel. These include:

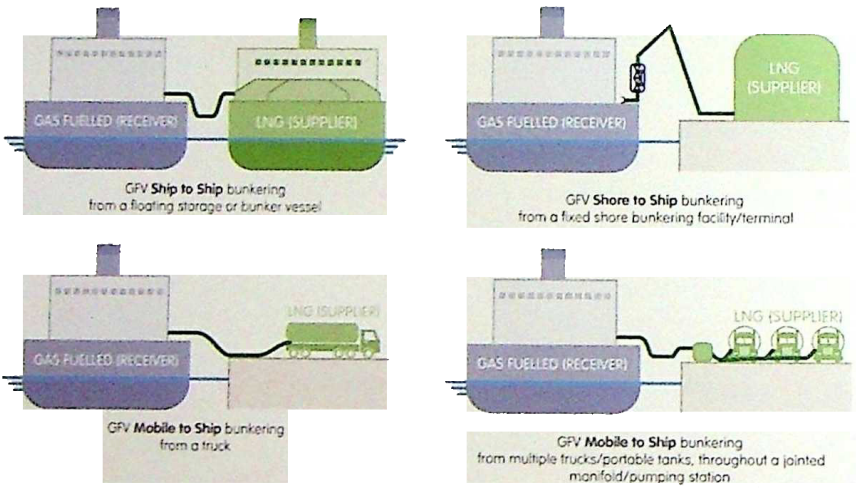
- the volume of LNG to be bunkered
- bunkering time and flow rates
- the location of the receiving vessel's manifolds

} *see* ***Lessons Learned 3-1***

The availability of appropriate bunkering facility suppliers in the area where the gas-fuelled vessel will operate also needs to be carefully considered.

Furthermore, a gas-fuelled vessel may be bunkered in various ways during its lifetime, so owners and operators should consider all likely future bunkering supply scenarios.

Figure 3.2: Example of bunkering supply scenarios



A fourth bunkering supply scenario, much less common than the main three scenarios above, is:

Portable LNG tanks used as ship fuel tanks

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In this application, a portable tank or tanks are connected to the receiving vessel fuel-supply system as part of the bunkering operation; when connected they effectively become the vessel's fuel tanks.

3.1.2 Ship-to-ship LNG bunkering

Bunkering via LNG bunker vessel (LBV) or barge is a common solution for traditional bunkering operations. It is carried out by a specifically designed vessel.

This method is preferred when a significant volume of LNG is to be transferred Capacities of the LNG bunker vessels currently in operation and under construction are in the range of a few hundred to thousands of cubic metres.

Undertaking bunkering with a bunker vessel gives flexibility over the location of bunkering as operations can be undertaken at the terminal(s) where a receiving vessel normally calls.

Ship-to-ship bunkering can be done with rigid arms, flexible hoses handled by crane, or hybrid systems (flexible hoses handled with rigid structures).

Figure 3.3: An example of ship-to-ship bunkering (Picture courtesy of Gasum)

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3.1.3 Shore-to-ship LNG bunkering

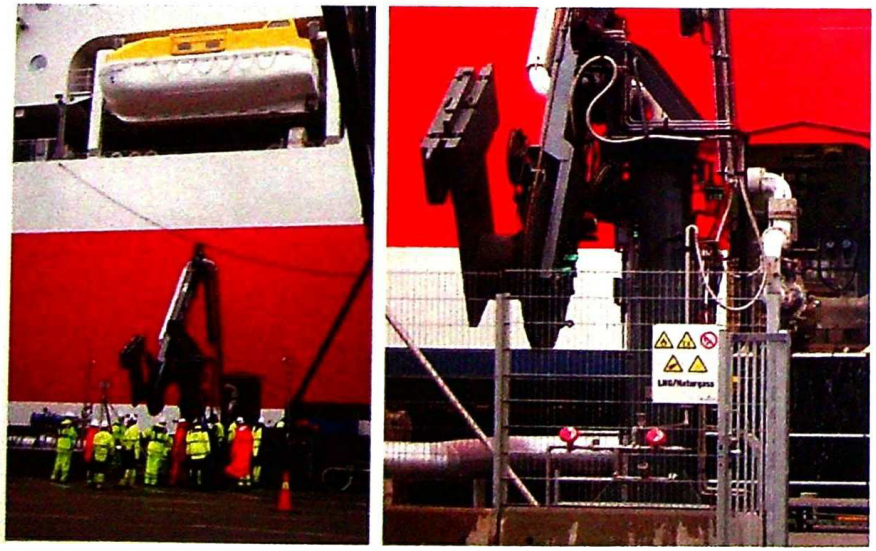
LNG bunkering from a fixed land-based installation takes place through a combination of rigid cryogenic piping and the use of hoses or a loading arm for final connection with the ship.

Shore installations can be divided into two categories:

1. Private installations designed and developed to match specific gas-fuelled vessel requirements and located within an existing terminal. Bunkering will normally take place simultaneously with other cargo operations.
2. Public or open facilities designed to bunker multiple different gas-fuelled vessel types. These are in a dedicated location to which the receiving vessels will come. Bunkering will not take place simultaneously with cargo operations.

In both arrangements the bunkering installation may be operated by either dedicated terminal personnel or the receiving vessel's own crew.

Figure 3.4: An example of shore-to-ship bunkering – by loading arm during commissioning (Picture courtesy of Gasum)



3.1.4 Mobile-to-ship LNG bunkering

LNG bunkering via a mobile bunkering facility, such as a truck or portable tanks, is the preferred option for the bunkering of small volumes of LNG. Bunkering by this method is flexible as it offers the possibility to bunker many different ships, in different port locations, with minimal infrastructure. It is particularly favoured for temporary bunkering arrangements or for one-off transfers, such as for tank cool-down/gassing up.

Duration of the LNG bunkering operation depends on the transfer capacity of the mobile bunkering facility, which is relatively small compared with ship-to-ship operations.

More than one truck may be needed to bunker a single ship, depending on the volume of fuel required.

It may be possible to increase the flow rate by simultaneously bunkering from multiple trucks, via a jointed mobile manifold/pumping station located on the quayside.

This type of operation is typically undertaken at a pier with sufficient space for a truck or portable tank to be located near the gas-fuelled vessel. Other variations, such as onboard operations, are also possible (see Section 8.4).

Special consideration needs to be given to any other operations being undertaken (SIMOPs) as the LNG truck may be in close proximity to other quay-based activities.

Figure 3.5: An example of truck-to-ship bunkering (Picture courtesy of Titan LNG)

3.1.5 Portable LNG tanks used as ship's fuel tanks

Unlike the other methods of bunkering, pre-filled LNG tanks are lifted or driven on board the receiving vessel and then connected to the vessel's fuel system.

These portable tanks replace or supplement the receiving vessel's LNG tanks. As the size of the portable tank is limited by road transport considerations, this only provides for small volumes of LNG.

Generally, this method is used only where vessel operations dictate that bunkering and cargo operations must take place simultaneously and the quay arrangement does not allow a bunker vessel or truck to get close to the side of the ship – for example, a roll-on/roll-off (Ro-Ro) ferry

When used in this manner, the tank must be connected to the ship's system before sailing. This bunkering method derives from some practices of oil fuel bunkering methods used in Ro-Ro ferries.

Notes:

1. Shipowners and operators should be aware that while the bunkering scenario "Portable LNG tanks used as ship fuel tanks" has been considered in development of these guidelines, this document does not specifically address the unique requirements of this type of scenario. So the recommendations given here should be used only for reference, with appropriate limitations.
2. Gas-fuelled vessels planning to use portable LNG tanks as ship's fuel tanks should follow the risk-based approach presented in Chapter 9 when considering bunkering operations:
   a. all parties involved in the bunkering operation should discuss the requirements of such a scenario – aiming, where possible, to minimise the differences with the recommendations in these guidelines
   b. furthermore, this process should follow a documented assessment that aims to meet or exceed the minimum threshold safety principles laid out in these guidelines

Lessons Learned 3-1: *Bunkering Supply Scenario Versus Volume and Flow Rate*

When deciding on the best bunkering supply scenario for a particular gas-fuelled vessel, several factors need to be considered, some of which should be taken into account at the early stages of the design of the vessel and the bunkering operation.

Two key factors are the volume to be bunkered and the bunkering duration.

Volume of LNG to be bunkered

Table 3.1: Volume of LNG versus bunkering supply type

A GFV with tank(s) of around 200 m³: [1]	The primary bunkering scenario is likely to be mobile-to-ship, using one or more trucks.
A GFV with large tank(s):	The primary bunkering scenario is likely to be ship-to-ship, with a bunker vessel moored alongside the GFV.
Shore-to-ship from a terminal:	This requires a vessel to go to a dedicated berth for LNG supply, which is only available in specific ports with terminals having small-scale facilities.

[1] Typically, a truck or container contains around 50 m³ of LNG and availability depends on the truck dispatch, logistics and local supply chain.

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Bunkering flow rates

The maximum flow rate at which bunkering can take place is limited by a number of factors, which include: the maximum discharge rate of the supplier; the size of LNG bunkering line and manifolds; the maximum allowable velocity through a single bunkering line; surge pressure considerations; vapour handling requirements; and so on.

Table 3.2: Flow speeds and Flow rates

Nom. Diameter		Flow Speed m/s											
mm	inch	2	3	4	5	6	7	8	9	10	11	12	Flow rate [m³/h]
50	2	16	23	31	39	47	55	62	70	78	86	94	
80	3	34	52	69	86	103	120	137	155	172	189	206	
100	4	59	89	118	148	177	207	237	266	296	325	355	
150	6	134	201	268	335	403	470	537	604	671	738	805	
200	8	232	349	465	581	697	813	930	1046	1162	1278	1394	
250	10	366	549	733	916	1099	1282	1465	1648	1831	2015	2198	

Low flow speed / rate — Intermediate flow speed / rate — High flow speed / rate

Note: The above flow rate values are calculated assuming LNG moving at full flow speed through the nominal bunkering line diameter of a Sch. 40 pipe ANSI B36.10 and no pressure drop has been accounted for.

Low flow speed and rate (From 2 to 4 m/s)	These values are likely to occur during ramp-up, ramp-down and topping-up operations.
Intermediate flow speed and rate (From 5 to 10 m/s)	These values are likely to occur during large bulk transfer for most bunkering operations. During the design and planning of a bunkering operation is it reasonable to assume that the flow speed and rate will generally be within this range.
High flow speed and rate (From 11 to 12 m/s)	These values may occasionally occur during large bulk transfer.

Flow speed exceeding 12 m/s	Flow speeds exceeding 12 m/s should not be used as they are likely to exceed the capacity of the bunkering equipment. REF: ISO 20159 §5 3.4: Flow rate of LNG through the transfer system shall not exceed 12 m/s, however, higher speeds can be locally acceptable in reduced passages, for example in the ERS, provided cavitation and vibration is acceptable.

Table 3.3: Bunkering line size versus bunkering supply type

Bunkering line size between 2" and 3"	The primary bunkering scenario is likely to be mobile-to-ship, using one or more trucks.
Bunkering line size from 4" upwards	The primary bunkering scenario is likely to be ship-to-ship, or shore-to-ship.

Notes:

1. Pressure surge calculations may be required to confirm or validate acceptable flow speed/rates during bunkering.
2. During the design of a gas-fuelled vessel, the designer is invited to discuss compatibility issues and requirements with the bunker supplier, if known.

3.2 LNG Bunkering – Stakeholders and Operational Roles

The bunkering operation can involve and impact many organisations with differing interests and views. The following chapters list the main and typical organisations and roles which might be involved or have an interest in the bunkering operation.

It should be noted that bunkering stakeholders and operational roles vary, depending on the bunkering supply scenario and the location and area where bunkering is planned. So it is the responsibility of all parties involved:

1. To identify at each stage the organisations and stakeholders with an interest in the bunkering operation or its location (see Section 3.2).
   a. organisations and stakeholders may be identified because they have an involvement in the operation, jurisdiction over the area, a legal interest, are operating in the same area or in proximity to the area where bunkering will occur, or the operation may directly or indirectly impact them
   b. their involvement as well as roles and responsibilities vary depending on the stage, from design to operation
2. To review the list of interested stakeholders and operational roles when there are changes in the bunkering location or area, or bunkering supply scenario.
3. To understand, contribute and participate in the development of the bunkering operation, as applicable to their area of interest or expertise. For example, designers may be involved in the early stages, when a bunkering facility or gas-fuelled vessel has been constructed and required to provide their expertise during a design risk assessment, while a terminal operator may be involved later on in an operational risk assessment.

3.2.1 Key stakeholders

The following stakeholders may be involved at various stages during design, planning, preparing or conducting a bunkering operation (see Table 3.4):

Table 3.4: Typical key stakeholders

Key stakeholder	General description and introduction	Remarks
LNG receiver	The owner and/or operator of a gas-fuelled vessel	In this publication, "LNG receiver" or "receiver" is used as a general term to refer to one or more organisations with an ownership, operational or legal interest in a gas-fuelled vessel. These may include: the owner, charterer or operator of a vessel.
LNG supplier	Supplier relates to the fuel owner or organisations mandated by them in the operation or development of a bunkering activity.	In this publication, "LNG supplier" or "supplier" is used as a general term to refer to one or more organisations, these may include: the owner, charterer or operator of a bunker vessel; the owner or operator of an LNG bunkering terminal; the manager of a road tanker fleet; an LNG producer, and so on.
Designer	Anyone involved in the design of a facility, vessel or equipment involved in bunkering.	
Regulator[1]	Typically, a national body with jurisdiction over a bunkering location (competent authority)	This can sometimes be the port authority.
Port authority[1]	A local authority with jurisdiction over a bunkering operation and location	
Terminal operator	Operator of a terminal where bunkering takes place.	This is not the operator of an LNG terminal or a bunkering facility but, for example, the operator of a container terminal where a GFV is bunkered.
Emergency services	First responders, firefighters, medics, police officers and so on.	
Port users	Stakeholders operating within the boundaries of a port, on both land and water	
Neighbouring facilities and the public	Stakeholders typically located outside the boundaries of a port	

Notes: Each of the parties/organisations listed above may be required to be involved in the development of a bunkering operation (see Chapters 4-7.) The list above is not exhaustive.
[1] Please also refer to the additional definition of competent authority below.

Note:
The **COMPETENT AUTHORITY** general term is used to define an organisation that has jurisdiction over the bunkering location, area, operation and/or assets involved and with a legal, operational or location-specific interest.

It should be noted that during the development of the bunkering operation from the design to the operational stage the competent authority is likely to change, or more than one organisation might have specific competent authority roles.

For example: during the design stage of a gas-fuelled vessel, a classification society on behalf of a flag state might act as competent authority. On the other hand during the planning and operational stages the national regulator as competent authority sets the risk assessment acceptance criteria while the port authority often acts as competent authority ensuring that the risk assessment process is satisfactory followed.

It is the responsibility of all key stakeholders in table 3.4 to identify who is the organisation acting as competent authority at any stage of the development of the bunkering operation.

3.2.2 Operational roles

Execution of a bunkering operation requires the involvement of a number of individuals and organisations to ensure that proper procedures are understood and followed. They are selected on the basis of their competence and training and their roles are typically defined during the preparation stage (see Section 6.4).

A brief description of each operational role is provided in Table 3.5, while the roles' specific tasks and responsibilities are discussed in detail later in this publication.

Table 3.5: Typical operational roles

Operational role	General description and introduction	Remarks
LNG bunkering organisation	The organisation staffing and operating a bunkering facility.	This role can be assumed by the operator of a bunker vessel, the operator of a shore bunkering facility, or the operator of a road tanker fleet, typically acting on behalf of the LNG supplier.
Receiving ship operator	The organisation staffing and operating a gas-fuelled vessel.	This role is assumed by the operator of a receiving vessel, following specific LNG training.
Master	The master of a vessel receiving LNG as fuel or of an LNG bunker vessel (for ship-to-ship operations) has overall responsibility for vessel safety and all its operations.	The master role may be performed by a deputy "acting master".
Person-in-Charge (PIC) [1]	The individual responsible for managing the bunkering operation on behalf of either the bunkering facility or the gas-fuelled vessel.	Both parties should define a PIC exclusively dedicated to the control and management of their side of the operation for supplying or receiving LNG.
Person in Overall Advisory Control (POAC) [2] [3]	The person with responsibility for overall management of a bunkering operation, facilitating coordination of operations between supplier and receiver.	This is a dedicated role and is typically assumed either by the supplier PIC or by the receiver PIC. The POAC acts during the actual bunkering of the fuel. A different and separate individual from the PICs may be appointed in certain circumstances. (see: Lessons Learned 6-1 When is a POAC Required?, on page 120)
Manifold watch/ hose watch	Personnel employed by the supplier and receiver to monitor equipment and execution during a bunkering operation	These personnel report to their respective PICs.

Notes:
[1] PICs' roles start during the preparation stage and continue through operation and completion.
[2] The POAC is only a coordination role, typically performed by one of the two PICs. It is active only when the supplier and receiver are alongside each other.
[3] The POAC role was established to ensure that during the critical steps of the bunkering operation only one individual coordinates the activities that need to be synchronised between the LNG bunkering organisation and the receiving ship operator.

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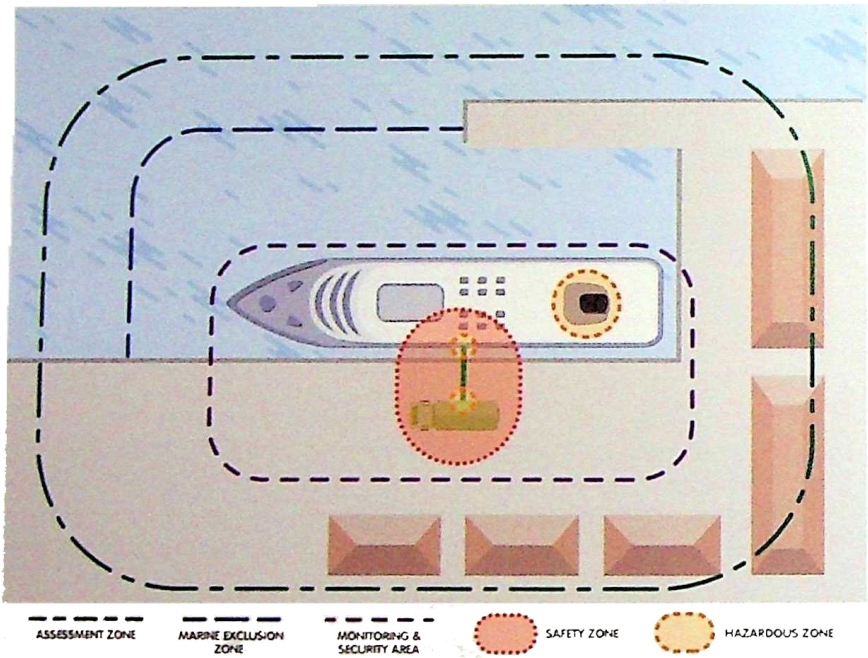
3.3 Hazardous, safety and controlled areas/zones in bunkering operations

Hazardous areas and controlled zones are defined around bunkering equipment and/or during the bunkering operation to control and mitigate the impacts of specific risks associated with the use of LNG and the bunkering operation itself.

SGMF defines five controlled areas or zones (see Figure 3.6):

Figure 3.6: An example of hazardous, safety and controlled areas/zones in LNG bunkering operations



- Assessment zone

The assessment zone is a three-dimensional space where low frequency, high consequence events could have an impact on other port users and the public in the surrounding area. The number of people and their vulnerability within the assessment zone will determine whether additional hazard mitigations are required to minimise this potential harm.

The assessment zone is primarily about the location of bunkering within the port environment but is also about the ship and terminal types.

Note:
This zone might be referred to by some jurisdictions as the 'external zone' as in SGMF publication *Recommendation of Controlled Zones During LNG Bunkering* (FP02-01, Ver 1.0).

- Marine exclusion zone

The purpose of the marine exclusion zone is to protect the bunkering vessel from other marine traffic, primarily by defining minimum distances and speeds for passing vessels.

The marine exclusion zone is within and part of the assessment zone and it should be defined as part of the process where the larger assessment zone is determined.

The precise definition of the marine exclusion zone is for each port to decide and implement in port rules, based on the specific port and ship studies, and as part of the assessment zone process. All ships and bunker vessels must comply with these rules.

- Monitoring and security area

The monitoring and security area is defined as the three-dimensional space inside which activities (including people and vehicle movements) need to be identified and monitored. This is to ensure they do not affect the safety of the bunkering operation by encroaching on the safety zone of the gas-fuelled ship, quayside or LNG bunkering infrastructure. Its primary purpose is to prevent people not involved in the bunkering process from having a negative impact.

The monitoring and security area, like the marine exclusion zone, must be within the assessment zone.

As the reasons for the monitoring and security area are many and wide-ranging, it is unlikely that it will be possible to define or justify its size by calculation. It should be considered as a an extra barrier around the safety zone. This area is only relevant during bunkering operations.

The monitoring and security area will always be larger than the safety zone.

Some restrictions on activities other than the LNG bunkering operation may be applied within the monitoring and security area.

- Safety zone

The safety zone can be defined as the three-dimensional envelope of distances inside which most leak events occur and where, in exceptional circumstances, there is a recognised potential for a leak of natural gas or LNG to harm life or damage equipment/infrastructure. The zone is temporary by nature, present only during bunkering. It may extend beyond the gas-fuelled ship/LNG road tanker/bunker vessel, interconnecting pipework, and so on, and will be larger than the hazardous zone.

Some restrictions on activities other than the LNG bunkering operation are likely to be applied within the safety zone while other activities may not be permitted at all. The safety zone is based on a defined gas leakage scenario (expert opinion) of what leak size may be likely at a specific risk level. It is not expected to affect any party outside the gas-fuelled vessel, bunkering facility, or terminal. And all staff operating in this zone should have procedures to follow, training, and where necessary PPE.

- Hazardous zone

The hazardous zone is a three-dimensional space in which a combustible or explosive atmosphere can be expected to be present frequently enough to require special precautions for the control of potential ignition sources.

Hazardous zones are always present but are addressed via appropriate design techniques and safety practices.

Hazardous zone boundaries are usually defined by codes or regulations, such as the IGF Code for gas-fuelled vessels and the IGC Code for LNG bunker vessels.

Note:
Owners, operators and designers should refer to the SGMF publication FP02-01, Ver 1.0 for specific guidance on the definitions and requirements of hazardous and safety zones.

3.4 LNG Bunkering – Introduction to the Key Stages

To facilitate a common approach across the industry, these guidelines suggest a four-stage approach to LNG bunkering:

- **Design stage** → Chapter 4
  - **Design for safety**
    To ensure LNG bunkering safety guidance and good practice are considered and correctly implemented during design and construction.
  - **Design for compatibility and efficiency**
    To ensure that assets are designed and constructed with future operational requirements for compatibility and efficiency in mind.

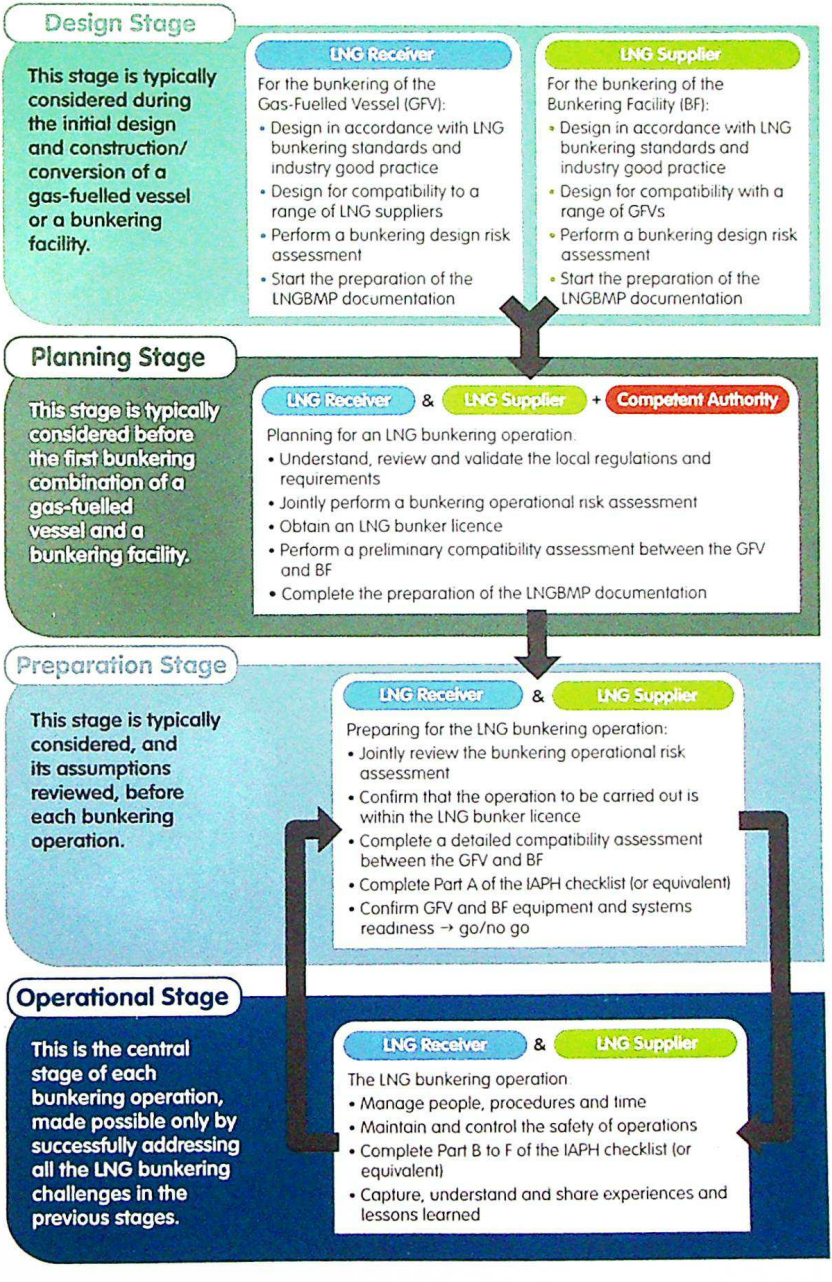
- **Planning stage** → Chapter 5
  - **Understand and fulfil local requirements**
    To identify and fulfil the bunkering area and location requirements set by the competent authority.
  - **Understand operational barriers**
    To identify barriers and challenges for future operations that may impact safety or compatibility between supplier and receiver.
  - **Outline operational requirements**
    To identify stakeholders' technical, safety and training requirements and to plan responses.

- **Preparation stage** → Chapter 6
  - **Understand and fulfil local requirements**
    To identify and fulfil the bunkering area and location requirements set by the competent authority.
  - **Understand operational barriers**
    To identify barriers and challenges for future operations that may impact safety or compatibility between supplier and receiver.
  - **Outline operational requirements**
    To identify stakeholders' technical, safety and training requirements and to plan responses.

- **Operational stage** → Chapter 7
  - **Maintain and control the safety of operations**
    To conduct operations in a safe and responsible manner.
  - **Manage people, procedures and time**
    To ensure efficiency and smooth operations.
  - **Continuous learning**
    To capture, understand and share experience and lessons learned.

Each stage addresses a range of issues and challenges related to the bunkering operation against specific goals (see figure 3.7).

Figure 3.7: LNG Bunkering Stages Structure



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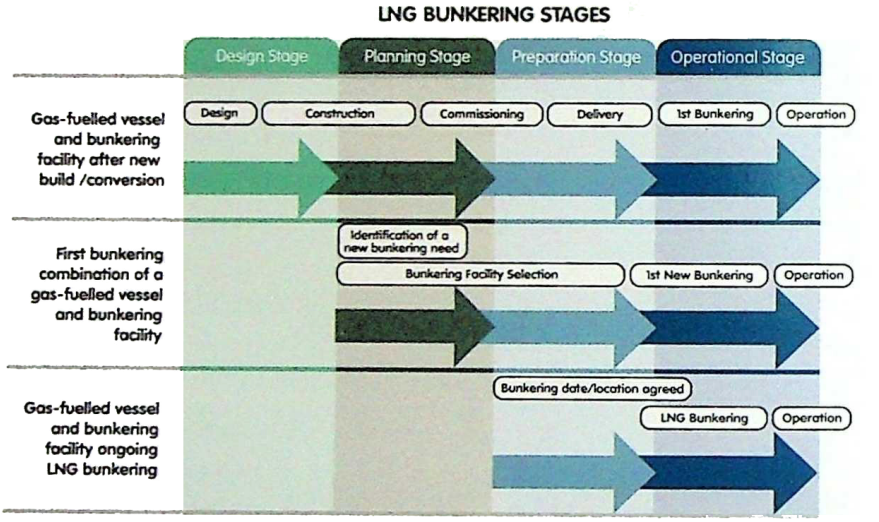
LNG bunkering stakeholders, as defined in Section 3.2, should consider and review the requirements for all four bunkering stages.

Figure 3.8 below provides guidance regarding at which point in time each of the stages should be considered. While there is no requirement to review each stage before each bunkering operation, it should be stressed that safe and efficient bunkering operations start with a robust and compliant design.

Figure 3.8: LNG bunkering stages versus operations



3.5 Codes, Standards and Regulations

LNG bunkering operations are regulated by several codes and standards. In addition to these, a number of guidelines have been developed over time to provide a common approach to operations and the sharing of good practice.

This section maps out the key elements of the regulatory regime with a focus on the bunkering operation and SGMF guidance (see Figure 3.9 and Table 3.6). A full list of applicable codes, standards and regulations is provided in Chapter 10.

Figure 3.9: A map of codes, standards and regulations

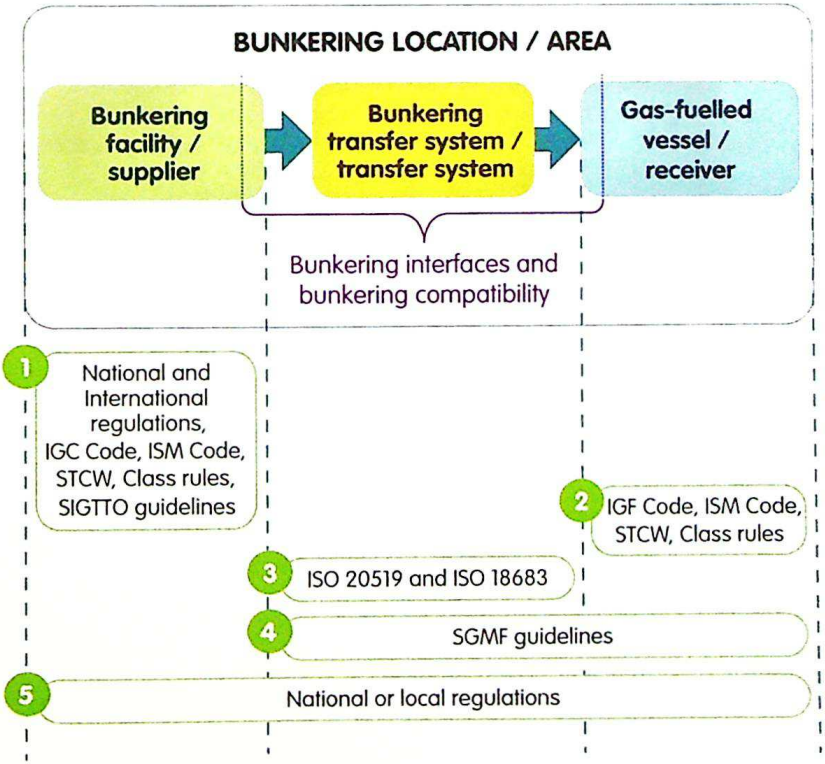


Table 3.6: A map of bunkering codes, standards and regulations

Codes, standards and regulations	Applicability	Remarks
1 **National and international regulations, IGC Code, ISM code STCW, Class rules, SIGTTO guidelines**	design requirements design safety operational safety	These set the requirements for the design, safety, and operation of a bunkering facility. For example. • a mobile and fixed bunkering facility will be interested in national and international standards requirements • a bunker vessel barge will focus on the IMO and Class requirements While none of these directly address the bunkering operation, the requirements can impact the compatibility of critical elements of the bunkering interface.
2 **IGF Code, ISM code STCW, Class rules**	gas-fuelled vessel design and safety	These set out the requirements for the design, safety, and operation of a gas-fuelled vessel, including the interfaces and onboard equipment involved in bunkering operations.
3 **ISO 20519 and ISO 18683**	bunker system and interfaces design and safety	These international standards directly address the bunkering operation by setting requirements for the design and safety of bunkering equipment, including the interfaces between gas-fuelled vessels and bunkering facilities
4 **SGMF guidelines**	bunkering facility interfaces and operations bunker system, interfaces, and gas-fuelled vessel design, safety, training, and operations	These industry guidelines directly address LNG bunkering by providing recommendations and good practice for all aspects of the operation, including design, safety and training.

Codes, standards and regulations	Applicability	Remarks
5 National or local regulations (port by-laws)	bunkering operation design, safety, training, and operations	These local and national standards vary, depending on the area and location where a bunkering operation occurs. While they tend to be general requirements developed by international bodies such as EMSA or IAPH, local administrations such as a port authority may develop a specific set of requirements to address local needs with which bunkering operations need to comply.

During the design and planning of a bunkering operation, LNG suppliers and receivers should:

1. Clearly identify applicable regulations and ensure these are understood by all the parties involved prior to operations and are implemented in the planning of bunkering.
2. Understand the local requirements or the lack thereof. Although international regulations are commonly applicable, national and local regulations may differ.
3. Discuss the bunkering plan with national and local authorities. Local authorities may enforce the regulations and define procedures for compliance.
4. Besides the statutory requirements in point 1, an LNG bunkering operation should comply with company and terminal procedures, and good practice guidelines. SGMF provides a list of publications (see Chapter 10) that should be read and used in conjunction with these guidelines. They provide guidance based on current good industry practice on various aspects of a bunkering operation, including:
   - vessel and equipment design and interfaces (manifolds, ESD and hose bunker system)
   - the definition of safety zones
   - SIMOPs
   - personnel competence and training
   - the custody transfer process

3.6 Bunkering documentation

Gas-fuelled vessels and bunkering facility owners and operators are responsible for producing and maintaining key LNG bunkering documentation that might be used during auditing, licensing, and risk assessment processes and referred to in the planning, preparation and during LNG bunkering operations. The content and use of the following key documents are described in this chapter.

1. The LNG bunkering management plan (LNGBMP) – see Section 3.6.1
2. The bunkering checklist - see Section 3.6.2
3. The bunkering compatibility checklist/report - see Section 3.6.3
4. The joint bunkering plan (JBP) - see Section 3.6.4

Notes:
While producing and maintaining key LNG bunkering documentation, it is essential to ensure compliance with local and international regulations, procedures, and requirements:

1. The form and number of documents to be prepared should be proportionate to the needs of the operations to be carried out.
2. It should not become a mere bureaucratic exercise, so repetitions and duplications should be avoided.
3. Their content and purpose should be checked with the local competent authority as these might differ by location and bunkering supply scenario.

3.6.1 The LNG bunkering management plan (LNGBMP)

What it is
The LNG bunkering management plan (LNGBMP) is a collection of all the documents needed for an effective and safe LNG bunkering operation. It describes the equipment and systems used, the bunkering operation process, and the safety measures that are in place.

What it is used for

The information in the LNGBMP is used to:

- inform risk assessment processes and compatibility assessments, and
- obtain, during the planning stage, the licence for LNG bunkering from the competent authority with jurisdiction over the bunkering operation/ location

Who it is prepared by, and when

The LNGBMP documentation is prepared and compiled by the receiving gas-fuelled vessel and the supplying bunkering facility during the design and planning stages.

It is typically prepared once for a gas-fuelled vessel and bunkering facility bunkering, and then referred to during subsequent bunkering operations.

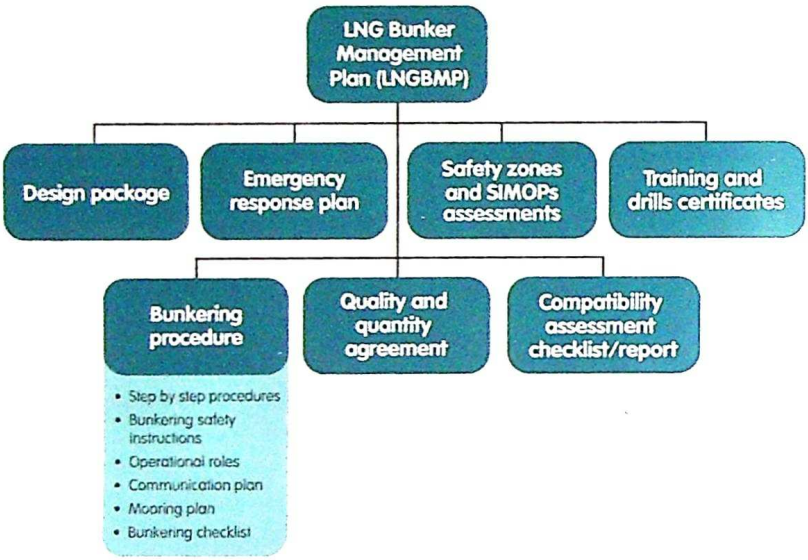
However, it should be noted that some of the LNGBMP documentation is prepared for a specific combination of a gas-fuelled vessel and bunkering facility at a specific location, so this might need to be updated or a new LNGBMP created if the bunkering operation changes, e.g. for a different location, vessel, etc.

What is included

A typical LNG Bunkering Management Plan (LNGBMP) should include the elements in figure 3.10 below. Further information on the content description of each of the documents of the LNGBMP can be found in Appendix A while further reference may be made to IACS recommendation No.142 § 1.5.

Note that figure 3.10 and Appendix A provide a view on the typical recommended set of LNGBMP documents, but this might vary depending on the competent authority which is to grant the bunkering licence.

Figure 3.10: Typical content of an LNGBMP



3.6.2 The bunkering checklist

What it is

The bunkering checklist is a mutual document that contains steps to be taken and confirmed by both the supplier and receiver during the bunkering operation.

It is also one of the documents included in the LNGBMP described in Section 3.6.1.

What it is used for

During the preparation and operational stages, the checklist is used by the LNG bunkering organisation and receiving ship operator to check and validate each step of the bunkering operation. These checks are typically carried out by the supplier's and receiver's persons in charge (PICs).

The point at which the bunkering operation is started is often considered as the point when the approved checklist is signed by both parties.

Who it is prepared by, and when
The bunkering checklist format should be prepared and agreed by the supplier and receiver during the planning stage and then checked/used in the preparation and operational stages.

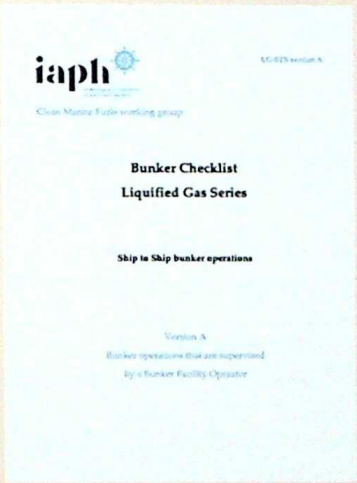
A new bunkering checklist is completed for each bunkering operation.

Note:
SGMF endorses the use of the International Association of Port and Harbour (IAPH) bunkering checklist. It is available in three versions for ship-to-ship, shore-to-ship, and truck-to-ship bunkering (see https://sustainableworldports.org).

The IAPH bunkering checklist – a free download – is widely used across the industry. The supplier and receiver should consider using this as a template instead of developing their own from scratch.

The standard framework of the IAPH bunkering checklist may be tailored by the supplier, receiver or regulator/ authority to specific operational requirements during the planning stage.

Figure 3.11: IAPH checklist 2021/2022 edition


iaph

Bunker Checklist
Liquified Gas Series

Ship to Ship bunker operations

The local competent authority may require or accept the use of different bunkering checklists in the area under their jurisdiction. The LNG supplier and receiver should therefore check the local requirements during the planning stage of the operation.

What is included
For the bunkering checklist content, refer to the IAPH checklist, which is divided into six main parts to be used at different stages of the operation. (Note that this publication refers to the 2021/2022 edition of the IAPH checklist.)

- Part A – Preparation Phase
- Part B – Pre-Bunkering Phase
- Part C – Preparation for Bunkering Phase
- Part D – Connection Testing Phase
- Part E – During Transfer Phase
- Part F – After Operation Phase

3.6.3 The bunkering compatibility checklist/report

What it is
The bunkering compatibility checklist/report is a mutual document that aims to:

- demonstrate that the safety and bunkering systems of the bunkering facility and the ship to be bunkered are compatible
- provide any recommendations or guidance that should be included in the bunkering procedure to ensure compatibility between supplier and receiver

It is also one of the documents included in the LNGBMP described in Section 3.6.1.

What it is used for
During the preparation stages, the bunkering compatibility checklist/report recommendations are used by the LNG bunkering organisation and receiving ship operator to prepare their own systems and equipment that are to be 'connected' to each other for the bunkering operation.

Who it is prepared by, and when
The bunkering compatibility checklist/report is prepared during a compatibility assessment process that should be performed in the planning stage and then reviewed in the preparation stage.

The bunkering compatibility checklist/report is typically prepared once for a gas-fuelled vessel and bunkering facility bunkering combination, and then

referred to and used during subsequent bunkering operations.

What is included
The bunkering compatibility checklist/report includes checks and recommendations on several items relating to the compatibility between the parties.

The content and description of the compatibility assessment process and checklist/report are discussed further in Section 3.7.

3.6.4 The joint bunkering plan (JBP)

What it is
The joint bunkering plan (JBP) is a mutual document that contains essential information about a specific bunkering operation from a bunkering facility and a gas-fuelled vessel in a defined location.

This document is typically requested by local competent authorities such as ports, that follow the IAPH bunkering checklist framework.

It can be seen as a short summary document of the information typically found in the LNGBMP documentation described in Section 3.6.1.

What it is used for
The JBP serves two main purposes:

- as a reference document for the local competent authority to ensure that the key elements of the bunkering operation have been addressed
- as a readily accessible information document used by the LNG bunkering organisation and receiving ship operator for reference and consultation during the preparation and operational stages

Who it is prepared by, and when
The JBP should be prepared and agreed by supplier and receiver during the planning stage and preparation stages.

The JBP is typically prepared once for a gas-fuelled vessel and bunkering facility bunkering combination at a specific location, then referred to during subsequent bunkering operations and revised if required.

What is included

The JBP should contain essential information for the LNG bunkering operation in a short, concise document (depending on the type and complexity of the bunkering operation).

Notes:

1. Information contained in the LNGBMP documents could be used to create the JBP (see Section 3.6.1) as the latter provides a handy summary for the local competent authority parties directly involved in the bunkering operation.
2. JBP content might vary according to the local competent authority requirements and bunkering supply scenarios. It is therefore suggested to refer to the IAPH bunkering checklist for guidance.
3. As far as possible, the JBP should be kept as concise and practical as possible (10-30 pages maximum), as it is intended as a brief and readily accessible information document.
4. Where applicable, the JBP could refer to documentation contained in the LNGBMP (see Section 3.6.1) to avoid unnecessary duplication.

3.7 Bunkering Compatibility Assessment

A bunkering compatibility assessment should be undertaken before any bunkering operation.

The main goal of the assessment is to confirm that the physical and operational interfaces between the bunkering facilities and the receiving gas-fuelled vessel are compatible so that bunkering can be completed safely.

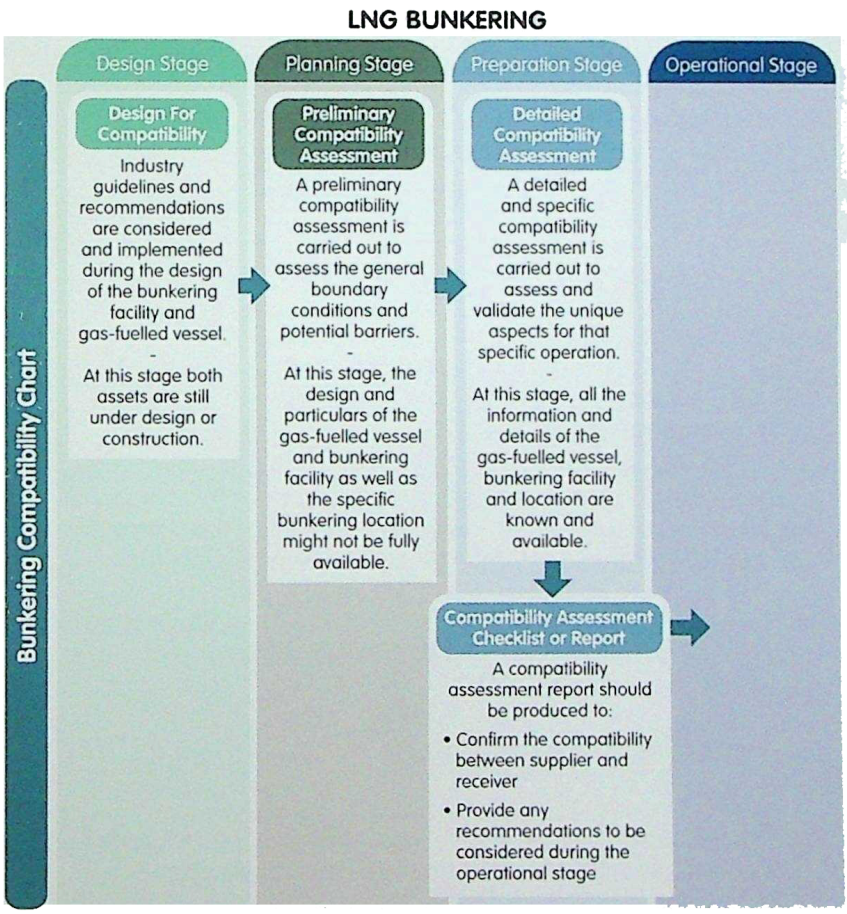
The assessment should confirm there is no aspect that prevents the LNG bunkering operation or introduces additional risks, and should provide any recommendations needed to ensure interface compatibility (see Chapter 7).

Port authorities and/or administrations with jurisdiction over the bunkering location may require proof of verification of bunkering compatibility as part of the LNGBMP documentation submitted in advance of operations (see Section 3.6).

3.7.1 Compatibility assessment process

The bunkering compatibility assessment should be considered a step-by-step process, starting from the design stage of each bunkering facility and gas-fuelled vessel through the planning and preparation stages of bunkering (see Figure 3.12).

Figure 3.12: The bunkering compatibility assessment process



The three main steps of the bunkering compatibility assessment process are:

1. **"Design for compatibility"** in the design stage (see Section 4.12)
   Industry guidelines and recommendations are considered and implemented during the design of the bunkering facility and gas-fuelled vessel to ensure their interfaces align with typical industry layout and good practice.
2. **"Preliminary compatibility assessment"** in the planning stage (see Section 5.10)
   A first assessment is carried out to assess the general boundary conditions and potential barriers. Recommendations may be issued to be considered at the preparation stage when bunkering equipment and interfaces are prepared.
3. **"Detailed compatibility assessment"** in the preparation stage (see Section 6.9)
   A detailed compatibility assessment is carried out to assess and validate the unique and specific aspects of each step of the operation and for each interface. Operational recommendations may be issued to be considered in the operational stage – for example, interface settings and connection procedures.
   If there is significant change in operational parameters or the external environment, the detailed compatibility assessment should be revisited. Note that some bunkering parameters can change from one operation to another, even between the same bunkering facility and gas-fuelled vessel – for example, pressure and temperature of the tank(s) or the requirement to use a vapour return line. So long as these variations are accounted for, a new detailed compatibility assessment is not required.

During the preliminary and detailed assessments, a checklist may be used to assist the process and record any recommendations. When completed, it should be included in the LNGBMP.

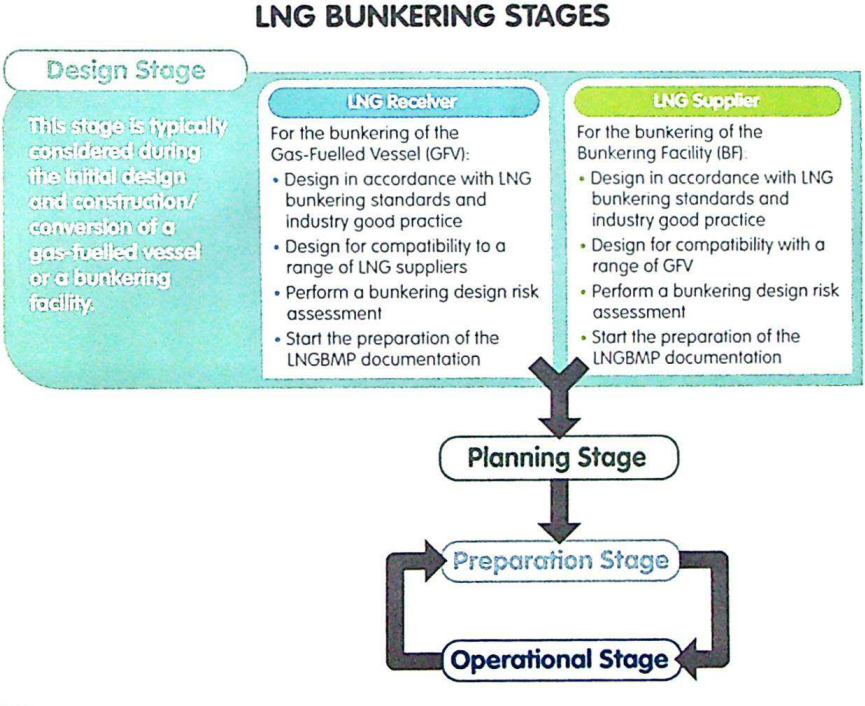
4. Design Stage – LNG Bunkering

The design of a gas-fuelled vessel or a bunkering facility is often a separate and independent process that involves a team of naval architects, mechanical and marine engineers, regulatory experts, and operators, collaboratively bringing concepts, constraints, and requirements into a design – and then making that design a reality.

4.1 General

When

The **Design Stage** spans from early planning and design of the bunkering facility and/or gas-fuelled vessel through to their construction.



Who

During the design stage, the future asset's owner and operator are likely to be deeply involved with designers and regulators in developing the bunkering facility's or gas-fuelled vessel's systems and associated equipment (see Section 4.2).

However, since this is an early stage, it is expected that:

- the supplier will not know the exact configuration of the receiving gas-fuelled vessel, and vice versa, so the two parties are likely to develop their bunkering design independently or partially independently from each other
- the owner and operator of the gas-fuelled vessel may not know the exact bunkering location and may have only a rough indication of the area where the vessel will trade
- an LNG bunker vessel owner and operator may have identified the likely operating area and LNG loading facilities but not the exact bunkering locations

Goals

During the design of the asset, "design for LNG bunkering" may not always be the central focus, particularly in the development of a gas-fuelled vessel. However, bunkering is an important future vessel operation that needs to be considered. This will ensure:

1. **Design for safety:**
   a. The gas-fuelled vessel, the bunkering facility and the bunker transfer system should be designed:
      i. to avoid LNG being trapped
      ii. to facilitate draining and purging after bunkering operations
      iii. to incorporate passive and active safety concepts early in the design
      iv. to allow safe bunkering operations, in accordance with industry standards and guidelines
      v. to prevent the release of LNG or fugitive gas, wherever possible, and to ensure that, if a leak occurs, it does not pose a risk to personnel and assets, or impact the environment

2. **Design for compatibility and efficiency:**
   a. Systems, equipment and interfaces should be:
      i. compatible with a wide range of LNG suppliers and receivers to maximise future trading opportunities and enhance flexibility
      ii. ergonomically designed to give personnel adequate access to key equipment items, controls, instruments and connections
   b. The bunkering gas-handling system should facilitate all the steps of a bunkering operation, including: cool-down, inerting, purging, warming up and de-bunkering.

Early consideration during the design stage of a bunkering facility or a gas-fuelled vessel of the recommendations, industry lessons learned, and good practices shared in this document and other SGMF publications will help to optimise bunkering compatibility and efficiency.

Failure to address the requirements for LNG bunkering during the design stage could lead to the following consequences:

- suboptimal or inefficient bunkering operations which take longer than necessary and/or impact other vessel operations such as cargo loading/unloading
- lost opportunities to simultaneously undertake LNG bunkering with other vessel operations
- additional capital expenditure to make later modifications to the gas-fuelled vessel, the bunkering facility, or the bunker transfer system to address compatibility issues
- unsafe operations and practices and avoidable harm to the environment

4.2 Key Roles and Responsibilities (Design)

Table 4.1 below summarises the key roles and responsibilities of stakeholders (see Section 3.2) who may be involved in the design stage of an LNG bunkering operation:

 © Society for Gas as a Marine Fuel

Table 4.1: Design stage – stakeholders' key roles and responsibilities

Design stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
LNG receiver (the gas-fuelled vessel owner and/or operator)	• Define the design requirements for the gas-fuelled vessel, including the bunkering system and equipment. • Carry out a bunkering design risk assessment for the gas-fuelled vessel, aiming to identify design mitigations early on.	Designers, regulators and suppliers may be involved during the bunkering design risk assessment of a gas-fuelled vessel.
LNG supplier (the bunkering facility owner and/or operator)	• Define the design requirements for the bunkering facility, including the bunkering system and equipment. • Carry out a bunkering design risk assessment for the bunkering facility, aiming to identify design mitigations early on.	Designers, regulators and suppliers may be involved during the bunkering design risk assessment of a bunkering facility
Designer(s) (including facility, vessel(s) equipment designers, as applicable)	• Develop the design of a gas-fuelled vessel, or a bunkering facility, including bunkering systems and equipment. • Take part in a bunkering design risk assessment, aiming to identify design mitigations/controls early in the configuration development.	
Regulator [1] (typically a national body with jurisdiction over the bunkering location; this can sometimes be the port authority)	• Overview and perhaps approve the design of a gas-fuelled vessel, or a bunkering facility, including their bunkering systems and equipment. • May take part in a bunkering design risk assessment, aiming to identify design mitigations early on.	At this stage a classification society acting on behalf of a flag state might also take this role.
Port authority [1] [2]	• May be involved on behalf of, or as part of, the regulator role.	
Terminal operator [2]	• May be consulted.	Depending on the intended location (when known) which may involve installations or activities onshore

Design stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
Emergency services [2]	• May be consulted.	Depending on the intended location (when known) which may involve installations or activities onshore.
Port users [2]	• May be consulted.	Depending on the intended location (when known) which may involve installations or activities onshore or restrictions on passing vessels.
Neighbouring facilities and the public [2]	• May be consulted.	Depending on the intended location (when known) which may impact installations or activities onshore and/or public areas.

Notes
[1] In some cases regulators and port authorities may have interchangeable roles
[2] This stakeholder may be involved when the bunkering activity falls within the boundaries of a port.

4.3 Key Activities and Considerations

Special considerations are needed during the LNG bunkering design stage, as discussed in the following sections. They provide specific recommendations and considerations by bunkering supply scenario, based on industry experience and good practice.

The key **Design Stage** considerations discussed in the following chapters are:

- bunkering supply scenarios
- bunker station design:
  - arrangement and layout
  - location on the vessel
- linked emergency shutdown (ESD) system
  - Bunkering Safety Link (BSL)
  - Emergency Release System (ERS)
  - gas and leak detection
- bunker transfer system
- measuring equipment (custody transfer)

- mooring and access
- hazardous area and safety zone
- risk assessment – design mitigations
- design for bunkering compatibility

Note:
LNG bunkering stakeholders should recognise that the key considerations above:

a. do not have an obvious hierarchy as to which is more important, with some assets, configurations and scenarios more sensitive or impacted than others
b. are strongly linked to each other and must be reviewed as part of an iterative process
c. are typical and general, and are not an exhaustive list; specific designs, installations, locations and operations may require considerations beyond those discussed in this chapter

4.4 Bunkering Supply Scenario

LNG can be supplied to a gas-fuelled vessel in different ways, as discussed in Section 3.1. While the choice of the primary supply method is often based on the quantity to be bunkered and the flow rate used (see Lessons Learned 3-1: Bunkering Supply Scenario Versus Volume and Flow Rate, on page 19). Bunkering will have an impact on the design of both the bunker station and vessel layout.

When deciding on how LNG will be bunkered, the following should be considered:

- Where will the gas-fuelled vessel operate, and in which area and location will bunkering take place?
- Will bunkering be undertaken simultaneously with other operations (SIMOPs)?
- How will the vessel be moored?
- Which side of the vessel will be used for bunkering: quay side or water side or both (at different locations)?
- What are the potential risks associated with each bunkering supply scenario and what mitigations and controls can be put in place?

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner, operator and designers

Considerations and recommendations

1. LNG bunkering operations differ from traditional oil bunkering operations and often from other LNG bunkering scenarios. Stakeholders should have an initial understanding of LNG bunkering operations before designing a gas-fuelled vessel and its bunker station.
2. LNG bunkering can require more preparation and time than traditional fuel oil bunkering. Additionally, areas around the bunker station and bunkering facility (hazardous and safety zones) require restricted access during bunkering, which may impact other operations; these may need to be stopped, restricted, or relocated. Careful consideration of bunker station design and location on the gas-fuelled vessel can prevent later disruptions and challenges during bunkering operations.
3. It is advisable to consider whether a gas-fuelled vessel, in its lifetime, may be bunkered using more than one bunkering supply scenario and to include such requirements during the design stage.

4.5 Bunker Station Design

The LNG bunker station arrangement, layout, and location on board a gas-fuelled vessel is a critical element of the bunkering operation and the main interface with potential suppliers (see Figure 4.2).

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner, operator and designers

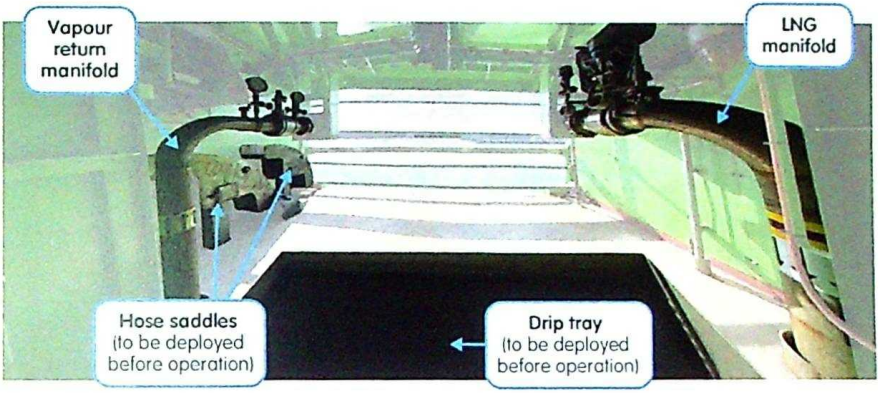
Considerations and recommendations

1. To ensure standardisation, compatibility and safe operations across the industry, owners and operators should consider SGMF guidelines on the bunker station regarding arrangement, layout and location (see Sections 4.5.1 and 4.5.2).
2. The use of spool pieces, reducers, blanks and coupling receptacles

connected to manifold flanges should be considered as standard practice – so their supply, installation and space requirements should be considered as part of the bunkering station design. Refer to Chapter 5 of SGMF's TGN 06-04 for guidelines on manifold interfaces.

3. Selection of an appropriate bunker station design requires an understanding of the type of LNG bunker transfer system that may be used, with important implications for the design of a receiving vessel. Specific guidelines on design aspects to accommodate a safe connection of a bunker transfer system to the gas-fuelled vessel manifolds are provided in Chapter 4.7.
4. Cryogenic protection should be provided at the bunker station wherever any spillage of cryogenic material or contact between cold bunker hoses/pipes and carbon steel structures could occur. These systems may be either active or passive, and include, for example, water curtains, gutters, drip trays and insulating blankets.
5. The bunkering operation will require the supply of several utilities. The bunker station design should include access to:
   a. nitrogen supply for purging and inerting:
      i. the recommendation for nitrogen purging and inerting supply is 7 barg (or above) and a volume production/capacity of three times the volume of the gas-fuelled vessel bunkering line
      ii. the design of nitrogen supply piping should consider all potential restrictions in the lines to ensure the expected flow rate is achieved
   b. nitrogen and/or compressed air supply for cleaning moisture and debris from connection flanges and couplings:
      i. the recommendation for compressed air supply is to have a minimum cleanliness specification of ISO 8573.1:2010 – Class 3.3.3
      ii. the recommendation for compressed air or nitrogen supply is 7 barg or above
      iii. hand wands with thumb-activated nozzles are recommended for blowing down surfaces
   c. water supply to assist with de-icing:
      i. when possible and available, supplies of both seawater and freshwater are desirable at the bunker station, including hose connections/equipment to supply water for spraying onto the transfer system

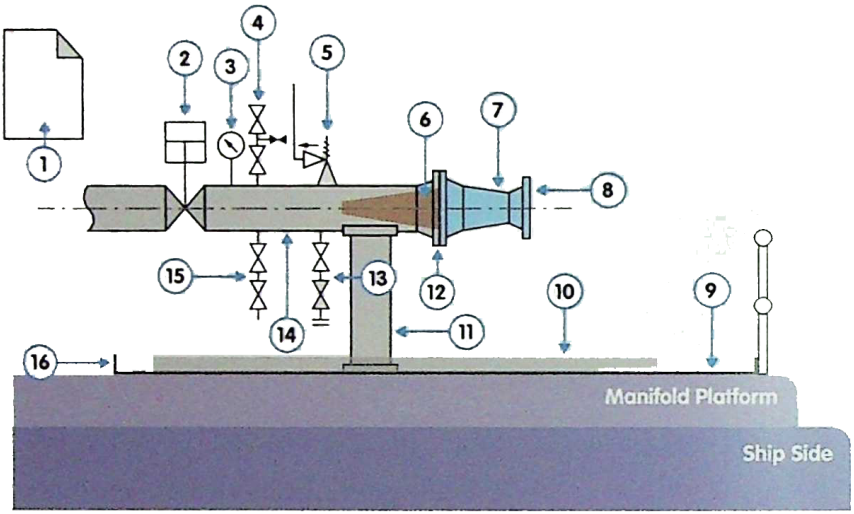
Figure 4.1: An example of a semi-enclosed gas-fuelled vessel bunkering station (Panoramic view – Picture courtesy of DEME Offshore)



4.5.1 Bunker station arrangement and layout

As part of the bunker station design, consideration needs to be given to the bunker manifold arrangements (see Figure 4.2). The strength of the manifold as well as the size, location, separation of liquid and vapour lines should be considered, in line with the proposed bunkering method and expected quantity of fuel to be bunkered.

Figure 4.2: A typical manifold arrangement

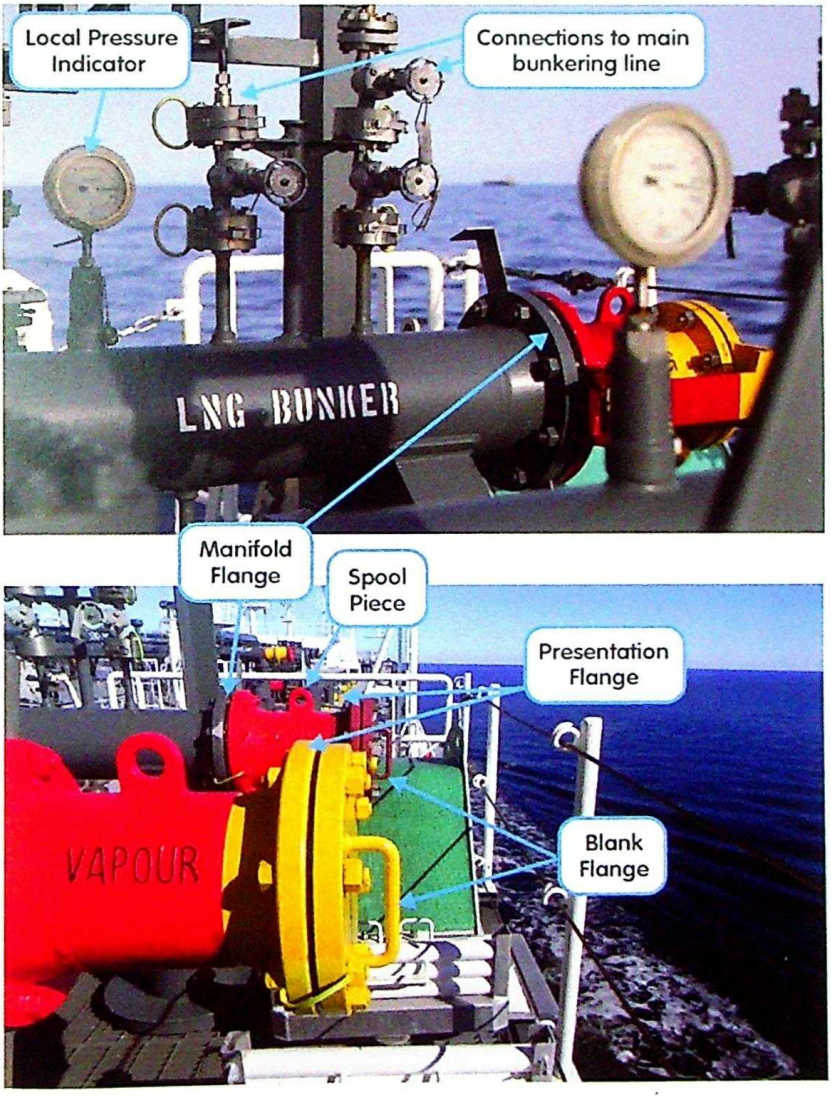


Note: The figure and location of items as shown are for illustration purposes only

1 P&ID bulkhead mounted drawing
2 Manifold first shut off or ESD valve
3 Local reading manifold pressure indicator
4 Double block to vent mast and bleed valve to open sampling point
5 Thermal relief valve
6 Strainer
7 Manifold spool piece reducer or coupler counterpart
8 Presentation flange
9 Low temperature protective sheathing
10 Drip tray
11 Manifold fixed support
12 Manifold flange
13 Drain valve
14 Distance piece
15 Remote or manual operated nitrogen valve with double isolation
16 Coaming

Note:
Owners, operators and designers should refer to the SGMF publication *Manifold Arrangements for Gas-Fuelled Vessels – TGN 06-04* for specific guidance on the overall functionality and design of the bunker manifold, to ensure standardisation and compatibility across the industry.

Figure 4.3: Examples of bunkering manifold arrangements (Picture courtesy of SCF Group)



4.5.2 Bunker station location

The location of the bunker station – including whether the bunker station is enclosed, semi-enclosed or located on the open deck – needs consideration with respect to several factors.

Note:
Owners, operators and designers should refer to the SGMF publication *Bunker Station Location: Considerations and Recommendations – TGN 06-07* for specific guidance on design principles for the location of the bunker manifold to ensure standardisation and compatibility across the industry.

The SGMF publication *Bunker Station Location: Considerations and Recommendations – TGN 06-07* provides guidance based on "Six LNG Design Aspects" (see Figure 4.4) with recommendations based on the bunkering supply scenario and ship type.

Figure 4.4: "Six LNG Design Aspects"

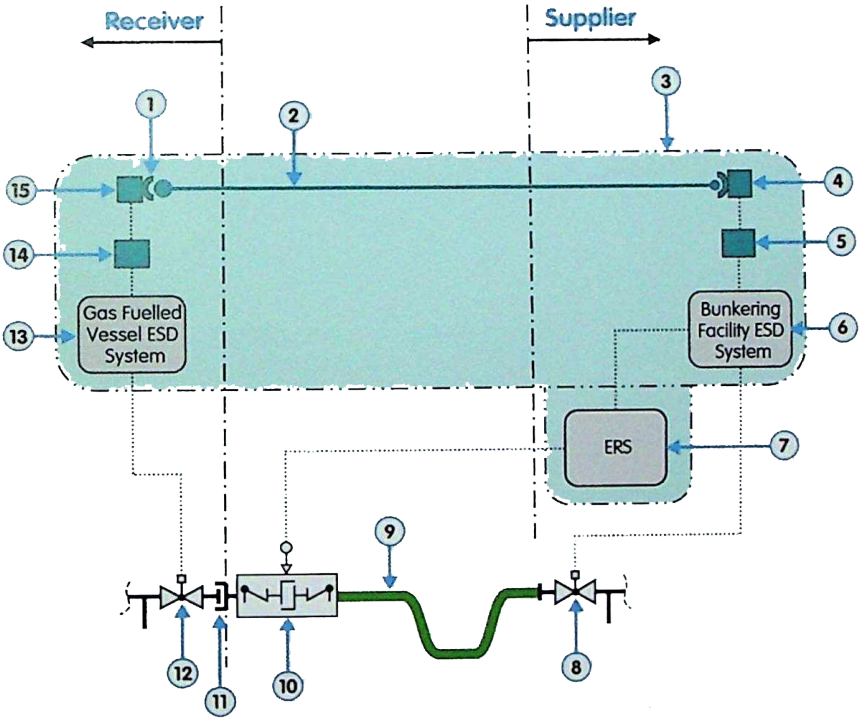
4.6 Linked Emergency Shutdown (ESD) System

The primary function of a linked ESD system is to ensure that both parties involved in the bunkering operation can shut down the transfer of liquid and vapour in a safe, coordinated and controlled manner.

The bunkering facility and gas-fuelled vessel should each be fitted with an ESD system. Before bunkering begins, the two ESD systems should be linked with a bunkering safety link (BSL) to create a linked ESD system (see Figure 4.5).

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner, operator and designers • Bunkering facility: owner, operator and designers

Figure 4.5: Typical layout for the ESD components of a hose-based bunkering system



1 BSL connector
2 BSL umbilical cable/hose
3 Linked ESD System
4 Supplier BSL connection box
5 Supplier BSL control unit
6 Supplier ESD system
7 Emergency Release System (ERS)
8 Supplier ESD Manifold Valve
9 Bunker Hose
10 Emergency Release Coupler (ERC)
(Note: ERC location might vary, e.g. located towards the supplier manifold)
11 Dry-Disconnect/Connect Coupling
12 Receiver ESD Manifold Valve
13 Receiver ESD system
14 Receiver BSL control unit
15 Receiver BSL connection box

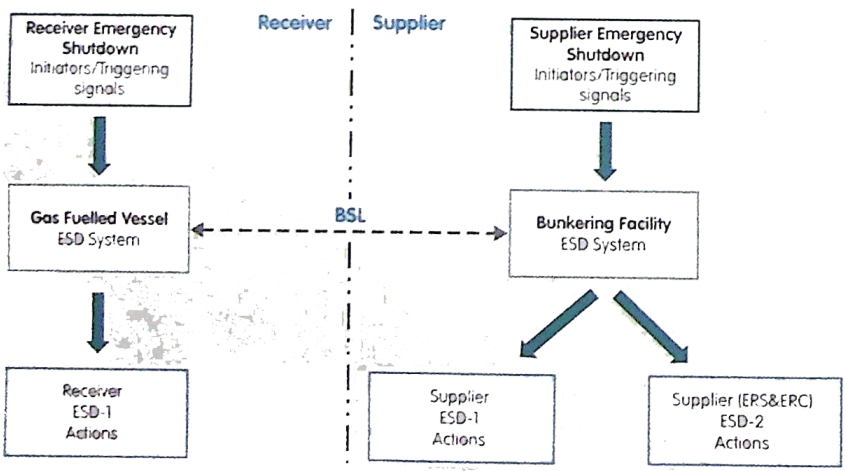
This section discusses a number of considerations and recommendations on the linked emergency shutdown system and its main components.

During a bunkering operation, the emergency shutdown process may be triggered automatically by various events/signals or activated manually by an operator (see Figure 4.6). However emergency shutdown initiators and actions can differ, depending on the bunkering scenario and the linked ESD systems in use.

A risk assessment workshop involving all the stakeholders in the operation – such as designers, owners and operators – should define the required initiators and actions, taking into account the bunkering scenario, and ultimately define the level of automation for the linked ESD system and its components.

Note:
In this document, "emergency shutdown" refers to the bunkering emergency shutdown – for example, ESD-1 events and actions. It does not include the other type of emergency shutdown – for example, the "ESD protected machinery space".

Figure 4.6: Emergency shutdown – initiators and actions



Note:
Owners, operators and designers should refer to the SGMF publication *Recommendations for linked emergency shutdown (ESD) arrangements for LNG bunkering – TGN 06-05* for specific guidance on the overall functionality and operation of the system to ensure standardisation and compatibility across the industry.

Considerations and recommendations

1. To achieve an effective and safe emergency shutdown, consideration should be given to the recommended initiators in Table 4.2 to be implemented as part of the linked ESD system logic, by the bunkering facility and the gas-fuelled vessel, as applicable (see Appendix G in TGN 06-05).
2. While actions following an emergency shutdown initiation for each system and bunkering scenario should be defined on a case-by-case basis, a set of recommended ESD actions is provided in Table 4.3 to be considered and implemented by the bunkering facility and the gas-fuelled vessel, as applicable (see Appendix H in TGN 06-05).
3. If any of the emergency shutdown initiators are triggered (see Table 4.2), bunkering operations should not resume until they have been identified and corrected (see Lessons Learned 4-1: Spurious Emergency Shutdown, on page 67).
4. On ESD bunkering activation, the manifold ESD valves on the receiving ship and bunkering facility, and any pump or compressor associated with the bunkering operation, should be shut down, except where this would result in a more hazardous situation (see Table 4.3). Note that, following an ESD bunkering activation, it is acceptable for gas consumers on the receiving vessel to continue to operate.
5. The closing time for gas-fuelled vessel and bunkering facility/supplier manifold ESD valves should not be greater than the time calculated in accordance with IGF Code § 16.7.3.7 or five seconds, whichever is the lesser ("if not demonstrated to be required at a higher value due to pressure surge considerations" IGF Code § 8.5.8).
   a. the bunkering line should be designed and arranged to withstand the surge pressure that may result from the activation of the ERS and quick-closing of the manifold ESD valves
   b. any pumps and vapour-return compressors should be designed to take into consideration the surge pressure in the event of ESD activation

6. An ESD bunkering activation should not lead to LNG being trapped in a pipe between closed valves without protection. Pressure-relief protection systems using pressure-relief valves (PRVs) should be provided, in accordance with applicable codes and standards.
7. Gas-fuelled vessels and bunkering facilities should have manual activation locations for the emergency shutdown. These should be positioned both:
   a. at a safe location – for example, outside the boundaries of the bunker station
   b. at a location where operators have a clear view of the bunker station area and the bunker transfer system equipment; the "clear view" may be provided via a suitable CCTV system

Table 4.2: Recommended emergency shutdown initiators (ref TGN 06-05)

ID	ESD Stage	Initiator	Application		Category
			Receiver	Supplier	
1	ESD-1	Operational Manual Trip (Stage ESD-1)	✓	✓	Minimum Requirement
2	ESD-1	Emergency Shutdown signal via BSL	✓	✓	Minimum Requirement
3	ESD-1	Overfilling tank(s) - high level	✓		Minimum Requirement
4	ESD-1	Tank pressure High or Low	✓	✓	**Recommended Initiator**
5	ESD-1	Loss of control actuating power at the ESD manifold valve.	✓	✓	Minimum Requirement
6	ESD-1	Over pressuring fuel supply system to the tank(s)	✓		**Recommended Initiator**
7	ESD-1	Electrical power failure	✓	✓	**Recommended Initiator**
8	ESD-1	Loss/failure of Bunkering Safety Link	✓	✓	Minimum Requirement
9	ESD-1	Gas/Leak detection	✓	✓	**Recommended Initiator**
10	ESD-1	Fire in bunkering manifold area	✓	✓	**Recommended Initiator**
11	ESD-1	Loss of communication	✓	✓	**Recommended Initiator**

ID	ESD Stage	Initiator	Application		Category
			Receiver	Supplier	
12	ESD-1	Loss of ability to manage BOG	✓	✓	Recommended Initiator
13	ESD-1	Fuel supply system automatic shutdown IGF 15.11.4	✓		Recommended Initiator
14	ESD-1	Excessive movements/ separations from Supplier and Receiver (stage 1 alarm)		✓[1]	Minimum Requirement
15	ESD-1	Abnormal pressure in the bunker transfer system		✓[1]	Recommended Initiator
16	ESD-1	ERS feedback (Health signal)		✓[1]	Recommended Initiator
17	ESD-1	Activation of ESD-2		✓	Recommended Initiator
18	ESD-2	Operational Manual Trip (Stage ESD-2)		✓	Recommended Initiator
19	ESD-2	Excessive movements/ separations from Supplier and Receiver (stage 2 disconnection)		✓[1]	Minimum Requirement

[1] Bunker transfer system owner

In Table 4.2 recommended emergency shutdown initiators have been divided between receiver and supplier and differentiated into two categories:

Minimum requirement: These initiators are an essential minimum requirement, and safety critical, and should always be implemented in the ESD logic.

Recommended initiator: These initiators are subject to the risk assessment as they may enhance mitigations against undesirable events, such as leaks, or reduce the probability that an emergency event escalates.

Further interpretation and recommendations on emergency shutdown initiators/triggers can be found in Appendix G of *Recommendations for linked emergency shutdown (ESD) arrangements for LNG bunkering – TGN 06-05.*

Table 4.3: Recommended emergency shutdown actions

Emergency Shutdown Actions SUPPLIER AND RECEIVER		
Stage 1 / ESD-1		
RECEIVER (GAS FUELLED VESSEL)		**SUPPLIER (BUNKERING FACILITY)**
Receives Emergency Shutdown trip signal from Supplier. --- Transmits Emergency Shutdown trip signal to Supplier via BSL.	← Or →	Transmits Emergency Shutdown trip signal to Receiver via BSL. --- Receives Emergency Shutdown trip signal from Receiver via BSL.
Where applicable, stops the vapour return flow, by tripping the compressors.		Stops bunkering transfer of liquid flow, by tripping the bunkering transfer pumps.
Closes Receiver's ESD Manifold Valve(s) in a safe, controlled and coordinated manner.		Closes Supplier's ESD manifold valve(s) in a safe, controlled and coordinated manner.
Stage 2 / ESD-2 – with active controlled ERC		
Initiates and performs Emergency Shutdown ESD-1 actions.		Initiates and performs Emergency Shutdown ESD-1 actions.
		Activates the Emergency Release System (ERS) which trips the closure and release (ESD-2) of the active controlled ERC.
Stage 2 / ESD-2 – with passive ERC "dry break away"		
		The passive ERC "dry break away" is pulled mechanically under load by the bunker hose or messenger wire trigging the closure and release (ESD-2) of the ERC.

4.6.1 Bunkering Safety Link (BSL)

The Bunkering Safety Link connects the supplier's and receiver's ESD systems. It is sometimes referred to as the "ESD link" or "ship-to-shore link". Its main purpose is to allow bidirectional exchange of emergency shutdown signals that can be independently activated by either party.

The BSL can also serve a secondary purpose: the transfer of voice and data communications.

A range of BSL technologies is available. The choice of BSL technology installed on a gas-fuelled vessel and bunkering facility is driven by multiple factors.

The bunkering safety link may be pneumatic, electric, fibre-optic or wireless. SGMF divides BSLs into three types, based on their differing technologies and functionalities:

- Type 1 – emergency shutdown signals only (low signal transmission speed)
  - pneumatic BSL
- Type 2 – emergency shutdown signals only
  - electrical 5-pin BSL
- Type 3 – emergency shutdown signals and voice and data communications
  - fibre-optic BSL
  - wireless BSL

The SGMF publication *Recommendations for linked emergency shutdown (ESD) arrangements for LNG bunkering – TGN 06-05* provides guidance for the selection of the correct BSL, based on the required functionalities and applications.

4.6.2 Emergency Release System (ERS)

An Emergency Release System (ERS) provides safe shutdown, transfer system isolation and quick release of hoses or transfer arms between the supplier and receiver to prevent product release at the time of disconnection.

It typically consists of an emergency release coupling (ERC) and interlocked isolating valves which automatically close on both sides, thereby containing the LNG or vapour in the lines (dry disconnect), and, if applicable, the associated control system.

ERS systems can employ passive or active ERC systems, allowing different levels of control over the emergency shutdown initiators and actions.

Considerations and recommendations

1. An ACTIVE CONTROLLED ERC is an emergency release coupler whose activation can be manually or automatically triggered by a control system and associated control switch/signal. The means of remotely operating the ERC should be positioned in a suitably protected area allowing visual monitoring of the bunkering system operation.
2. A PASSIVE "DRY BREAK-AWAY" ERC is an emergency release coupler activated only by applying a set "break-away" load to the ERC itself. Break-away load is typically a mechanical tension applied at the ERC collar in response to the gas-fuelled vessel and bunkering facility drifting away from each other.
   a. the passive ERC "dry break-away" needs to be suitably certified for the range of loads likely to be exerted during bunkering
   b. emergency shutdown ESD-1 should be initiated before the forces applied to the passive ERC reach the level where the coupling disconnects (ESD-2)
   c. the passive ERC "dry break-away" should be configured within the transfer system so that – in the worst expected conditions for current, waves and wind – it will not be subjected to excessive axial and shear forces likely to result in loss of tightness or opening of the coupling. Moreover, the hose "maximum working load" should not be exceeded; when the safe working envelope of the transfer system is exceeded, the passive ERC should operate
3. For ALL TYPES OF ERC, whether passive or active:
   a. during the bunker transfer operation personnel should not be in the vicinity of the ERC in case of sudden activation
   b. care should be taken that, in the event of an ESD-2 disconnection, the hoses do not become snagged and backlashing hoses do not harm people or damage equipment

c. full operating instructions, testing and inspection schedules, necessary records and any limitations of the ERS and ERC should be detailed in the ship's operating manuals

4.6.3 Gas and leak detection

Effective and timely detection of any gas or liquid leak is essential if bunkering is to be executed safely.

Detection may be achieved by instrumented systems comprising gas sensor(s) around the bunkering area, temperature sensor(s) in drip trays, thermal imaging or alternative sensing as appropriate, by visual means, or by a combination of the above.

Gas and leak detection should be provided around the supplier's and receiver's bunker stations and around the bunker transfer equipment.

Instrumented gas and leak detection is a recommended initiator for the bunkering emergency shutdown (see Table 4.2) so that a leak event initiates ESD-1 automatically or manually. This choice might provide an enhanced means of mitigating the spread of a gas leak in bunkering safety zone where, in exceptional circumstances, there is a recognised potential of harm to life or damage to equipment/infrastructure as result of a gas leak. (See Section 5.3.6 of the SGMF guideline *FP02-01, Recommendation of Controlled Zone During LNG Bunkering*.)

Reference should be made to leak detection in the ducting around the bunkering lines, as defined by the IGF Code, 15.5.3.

Considerations and recommendations

1. Gas detection devices can be significantly affected by certain weather conditions and design arrangements – for example, forced ventilation point rather than area detection may be required. The following factors need to be considered during design:
   a. a gas dispersion analysis may be used to identify the critical locations and the extent of the Lower Flammable Limit (LFL) range where gas detectors should be fitted to enable early detection of any leakage

   b. gas detectors should be self-diagnosing/testing and the designers/ builders of the systems should consider access and maintenance provisions for servicing
2. CCTV monitoring is recommended, especially where an unattended bunker station is operated.
   a. the CCTV should provide images of the bunker connection and also if possible, the bunker hose so that movement of the transfer system during bunkering is visible
   b. consideration may be given to the use of thermal imaging equipment for leakage detection, especially in enclosed or semi-enclosed bunkering stations
3. For a bunker station (on the receiving ship) or discharging station (of the bunker facility), the following safety devices should be considered/in place:
   a. gas detector(s) in suitable location(s), taking into consideration the rate of dispersion of cold vapour
   b. oxygen sensors, in proximity to nitrogen storage or connection (typically used in enclosed or semi-enclosed bunker station)
   c. low temperature detection sensor(s) installed in the drip trays, or
   d. any combination of the above to immediately detect leakage
4. If gas and leak detection is an automatic initiator for the bunkering emergency shutdown, it should be noted that:
   a. gas detectors activate spuriously quite regularly. (Increasing concentration threshold alarms may help to identify false alarms)
   b. care should be taken to ensure that ESD is automatically triggered only when gas is confirmed – this usually requires two adjacent gas detectors alarming so that one detector alarming alone does not operate the ESD immediately

Lessons Learned 4-1: *Spurious Emergency Shutdown*

Emergency shutdown can be triggered by a number of initiators (see Table 4.2). This can be for a legitimate reason but in some cases spurious shutdowns may also occur.

With the cause of an emergency shutdown identified, subjected to troubleshooting and cleared, according to the agreed bunkering procedure, operations may resume.

Operators should be aware of the risk of overriding any emergency system and emergency shutdown trigger or initiator, the consequences of which should be considered and fully understood by all parties and site personnel.

1) Any activation of the bunkering emergency shutdown should be investigated and corrected before any further transfer takes place.
   a. it is especially important to recognise that recovery from shutdowns (emergency or otherwise) often takes longer than expected
   b. the designers and programmers of the bunkering control system should consider the cause and effect of bunkering emergency shutdown and be mindful of the time it takes to identify and correct a shutdown
2) Bunkering emergency shutdown actions (see Table 4.3) should not be overridden.
   a. overriding or deactivating a specific trigger or initiator excludes its signals from the ESD logic while overall ESD system functionality is maintained, in case a different initiator is triggered – for example, a trigger initiator can be deactivated because it is faulty while the ESD system will continue to activate an emergency shutdown if a different initiator triggers it
   b. operators should have in place strict procedures and policies on how and when emergency shutdown initiators may be overridden, based on a risk assessment
   c. under such procedures – and the direct control and authorisation of the PIC, POAC and master, as applicable – overriding an emergency shutdown trigger or initiator may allow the operator to cycle closed

valves back to the LNG tank to relieve pressure, rather than fully relying on the pressure-relief valves protecting the isolated sections of piping. This may allow more time to troubleshoot and clear the shutdown before resuming operations

Lessons Learned 4-2: *The Use of Passive Versus Active ERCs*

Emergency Release Couplers (ERCs) can be active or passive, depending on their functionality:

- an actively controlled ERC can be triggered manually or automatically by a control system and associated control switch/signal
- a passive ERC "dry break-away" is triggered only by applying a set "break-away" load to the ERC itself

While the choice of ERC to be used is in part at the discretion of the parties involved in the bunkering operation, the following configuration is recommended (see Section 4.6 and Appendix H of TGN06 05):

Suggested for all bunkering operations and required for high bunker rates >150 m^3/h:

- a fast-acting fully- or semi-automated linked ESD system (requiring no or limited human interaction) which stops the transfer in as little as 10 seconds
- a Type 2 or above BSL and an active ERC controlled remotely by an ERS

Acceptable for low bunker rates ≤ 150 m^3/h:

- a fully manual linked ESD system which requires multiple human actions and acts in up to 10 minutes
- a Type 1 BSL and a passive ERC "dry break-away"

This ERC and BSL configuration is often used when the supplier is a mobile bunkering facility (truck or portable tanks). Note that where a passive "dry breakaway" ERC is selected, calculations must be performed to ensure that the loads transmitted to the ERC , to the self-sealing quick release coupler (QC/DC), to the gas-fuelled vessel manifold, and to the bunkering facility bunkering line, are all within their respective design limits.

Lessons Learned 4-3: *Leak Detection Versus Emergency Shutdown*

Leak detection is a recommended bunkering emergency shutdown trigger or initiator (see Table 4.2) for the supplier and receiver ESD systems because its integration into the emergency shutdown logic can enhance response time if a leak occurs. However, leak-detection systems and sensors are not always reliable, and can be falsely triggered, thereby initiating a spurious emergency shutdown.

1) Designers should consider the reliability of leak-detection systems and sensors when these are directly linked to the ESD system and to an automatic bunkering emergency shutdown.
2) Leak-detection systems should be installed according to manufacturers' recommendations to ensure correct operation. Any alarm activating an emergency shutdown requires investigation and rectification.
3) Based on a risk assessment approach, the automatic bunkering emergency shutdown by leak detection may be automatically triggered:
   a. if specific systems and sensors detect an increasing concentration of gas that activates sequential threshold alarms up to a defined concentration, when the ESD signal is initiated
   b. if two or more sensors detect a leak in the same area
   c. after a predetermined time delay, where an alarm alerts the operator but no corrective action is taken
4) The options in point (3) above should be application and location specific.
   a. designers, owners and operators should consider how and where such solutions may be suitable
   b. crew should be trained accordingly to recognise and address leak scenarios, both legitimate and spurious

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4.7 Bunker Transfer System

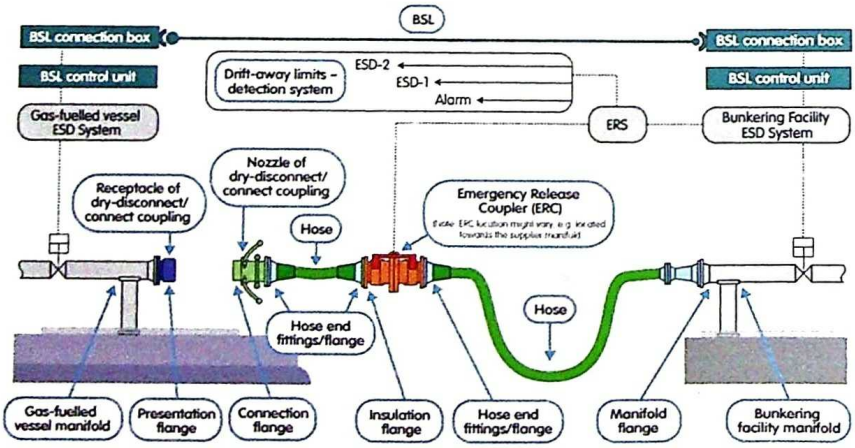
A bunker transfer system can be a loading arm made of articulated piping, a transfer hose solution, or a combination of the two, allowing the transfer of liquefied gas between a fuel supplier and a gas-fuelled vessel (see Figure 4.7).

The primary design objective is the safe transfer of cryogenic liquid. Not all LNG bunkering operations will fully match the bunker transfer system components and layout described in this section, depending on the results of risk analysis and recommended controls.

Key activity stakeholders (see Section 3.2)	
Who:	• Bunkering facility: owner, operator and designers • Bunker transfer system designer

For the purposes of this document, the "supplier" is the owner and operator of the bunkering facility. In some circumstances, the "receiver" – the owner and operator of the gas-fuelled vessel – may also own the bunkering facility.

Figure 4.7: Example layout of hose bunker system components (note that the locations and layout of components may vary from one installation to another)



Note:
Owners, operators and designers of bunker transfer systems should refer to the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN 06-06* for specific guidance on the functionality and operation of bunker transfer systems employing hoses.

Considerations and recommendations

1. The **bunker transfer system** for liquid and vapour transfer – whether loading arm, flexible hose or a combination of these – should:
   a. be designed and fit for marine LNG bunkering operations, in accordance with ISO 20519, ISO/TS 18683 and industry guidelines
   b. be designed and sized to compensate for any relative movement between the supplier and receiving vessel due to environmental conditions, within a defined operating envelope
   c. be able to compensate for draft and tidal changes, as applicable, over the whole duration of a bunkering operation
   d. be designed so that connection to the receiving manifold(s) can be achieved in an efficient and safe manner, where possible by no more than two people
   e. be able, in a drifting scenario where a vessel breaks away, to extend and disconnect the bunker transfer system from the receiving vessel without damage to its structural integrity
      i. ESD-1 and ESD-2 drift-away limits (or vessel separation) should be set to ensure that the two stages of the ESD are sequential, allowing sufficient time and payout for the procedure to be completed and the ERC released
      ii. consideration should be given to the acceleration and velocity of drift likely to occur if the mooring system fails, taking into account the range of vessels likely to be bunkered
   f. be able to withstand the forces and acceleration exerted on the system and its equipment following an ESD-2 disconnection
2. The receiving vessel **bunker station** should:
   a. allow the bunker transfer system to be brought into the bunker station and be connected to the manifold in one operation
   b. be ergonomically designed to allow enough space and working area for the personnel connecting the bunker transfer system to the manifold(s)
   c. be designed to capture or control any accidental leakages from the

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bunker transfer system including its connectors

d. be designed to withstand loads exerted by the bunker transfer system on the manifold and other supporting structures

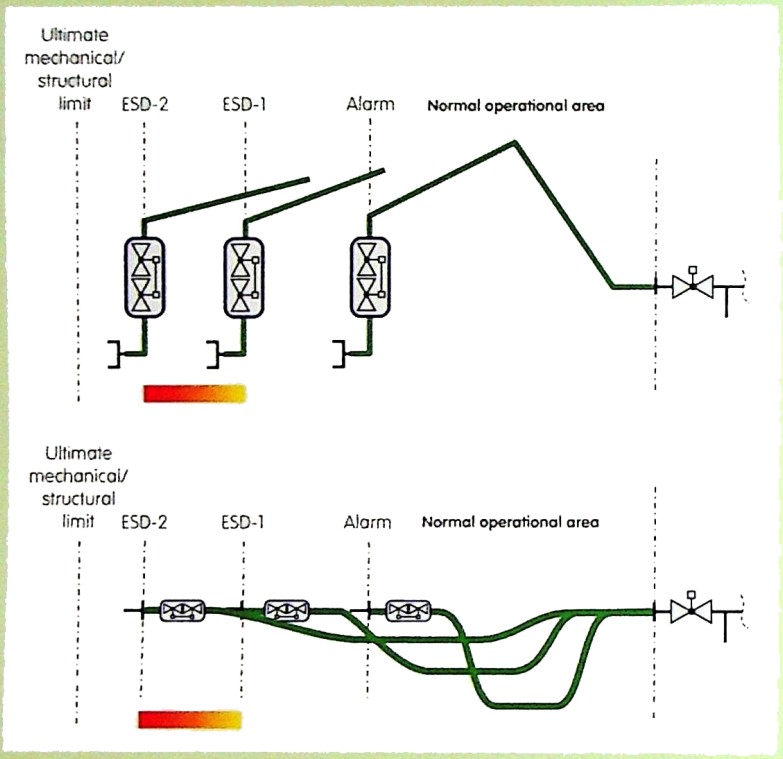
3. When hose bunker transfer systems are used, special consideration should be given to how the hose(s) will be supported.
   a. hose bunker systems and their hoses are heavy and have high bending and torsional stiffness, which typically increases when the hose is under pressure at cryogenic temperature. It is unlikely that personnel will be able to lift or bend a hose into position manually without some mechanical means of support
   b. hoses are characterised by some or all the following:
      i. static minimum bending radius
      ii. dynamic minimum bending radius
      iii. storage and operational coiling minimum bending radius
      iv. total length – rigid length – flexible length
   c. the characteristics of hoses can vary substantially by hose type and diameter. Bunkering operators should familiarise themselves with these before using hoses. Moreover designers of hose bunker systems should take this into account
   d. hoses should be arranged with enough slack to allow for all possible relative movements of the receiving ship and bunkering facility
   e. hoses should be supported so that the allowable dynamic minimum bending radius is not exceeded during transfer between vessels or while being connected to the receiving vessel manifolds
   f. lifting and supporting devices should be electrically insulated and should not impair the operation of any emergency release coupling or other safety device
   g. lifting arrangements should allow correct operation of the ERC and be arranged to prevent the hoses falling. If an ERC were to operate, both sides of the hose should remain suitably supported
   h. bunker stations should be equipped with lifting and supporting arrangements of suitable capacity to handle hoses and associated equipment

Lessons Learned 4-4: Hose Bunker Transfer System Operating Envelopes

The owner and operator of a bunker transfer system should define the operating envelopes of the equipment during the design of a bunkering facility, along with system operating procedures.

1) The operating manual/procedure of the hose bunker system should specify the weather operating envelope for each of the following stages:
   a. system deployment
   b. operation
   c. system retrieval
   d. the weather operating envelope should include, as a minimum, information for each of the stages on the allowable:
      i. wind speed and direction
      ii. waves and swell height, period and direction
   e. consideration should be given to the type of hoses used. Some hose types are more capable than others of withstanding frequency and amplitude of vessel movement during bunkering. Some will compensate only quasi-static movements with slow changes of draft or tide
2) The design of the hose bunker system and the minimum hose length should take into account drifting scenarios commensurate with the environment where the bunkering will take place. A study should be undertaken by the bunkering facility to determine the acceleration and velocity of drift likely to occur if the mooring system fails, taking into account the range of vessels likely to be bunkered. The study should:
   a. consider the following elements, as applicable:
      i. wind speed and direction
      ii. current and bank effect
      iii. tidal/draft range
      iv. change of draft trim and list of both vessels, especially during SIMOPs
      v. wave and swell height, period and direction
      vi. surge from passing vessels
      vii. inadvertent operation of vessel's propulsion or mooring system
      viii. ice floes
   b. provide quantifiable operating boundaries in x, y and z directions (see Figure 4.8)

Figure 4.8: Typical bunker system ESD limits



3) The operating manual/procedure of the hose bunker system should specify/include the:
   a. maximum allowable pressure of the whole system and its main components – for example, hose and ERC
   b. surge pressure analysis, taking account of valve closing times and locations
   c. static and dynamic load verification, considering the following loads and nodes

Loads and Forces	Nodes and Application Points
• Bending moment – static and dynamic	• Gas-fuelled vessel presentation flange
• Axial load – static and dynamic	• DD/CC seal (if applicable)
• Torque – static and dynamic	• ERC collar
	• Hose flanges/end fittings

4.8 Measuring Equipment

The LNG fuel transfer quantity and quality measurements required, and the measuring equipment used for custody transfer, depend on the process used and can vary from installation to installation.

While measuring equipment technologies are not discussed in these guidelines, consideration should be given to them during the design stages since they are a part of bunker transfer process equipment.

Key activity stakeholders (see Section 3.2)	
Who	• Gas-fuelled vessel: owner, operator and designers • Bunkering facility: owner, operator and designers

Note:
Owners, operators and designers should refer to the SGMF publication *Contractual Guidelines – Quantity and Quality – FP05-01, Ver1.0* for specific guidance on custody transfer principles, requirements and measuring equipment technologies.

Considerations and recommendations

1. At the design stage, the measurement method required and the equipment to be used (flow meters and so on) should be selected and located to minimise disruption to the flow of LNG and to prevent pressure surge, excess generation of boil-off gas (BOG), or pressure losses in the transfer system.

2. Different installations may employ different types of equipment or, in some cases, none. Quantity transfer measuring equipment is commonly found on a bunkering facility but less so on a gas-fuelled vessel (see Lessons Learned 4-5 How Bunker Vessels Measure Composition and Quantity, on page 76).

Lessons Learned 4-5: *How Bunker Vessels Measure Composition and Quantity*

This section discusses how LNG composition can be measured or estimated during bunkering custody transfer, depending on the different bunkering facilities, their equipment, and the delivery supply chain.

Because of the growing number of LNG bunker vessels in operation or due to be launched, in June 2020 SGMF asked a number of LNG bunker vessel owners and operators what system or systems were being used on board to calculate LNG composition and quantity, as part of bunkering custody transfer. The results are collected below.

Survey results

Responses were collected from ten bunker vessels, representing about 70% of the vessels currently operating or due to be launched by the end of 2020.

As most bunker vessels have more than one method of measuring LNG composition and quantity, they have been divided as follows:

- primary, preferred and/or usually used method
- secondary or optional method, either requested by the receiver or used in some circumstances as an alternative or backup to the primary method

Figure 4.9: LNG Composition Calculation Methods

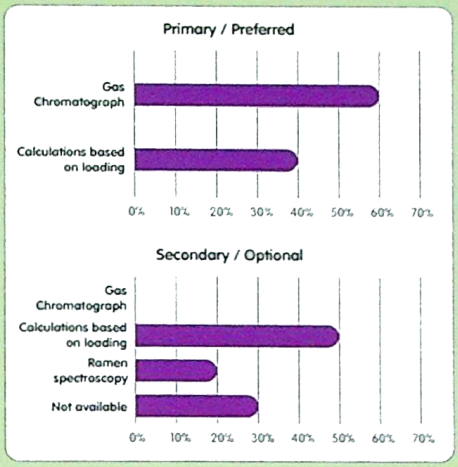
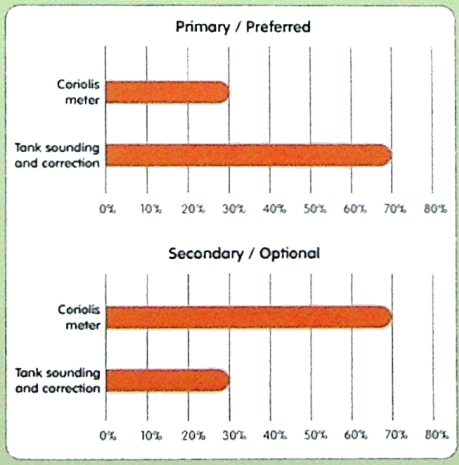


Figure 4.10: LNG Quantity Measurements Methods



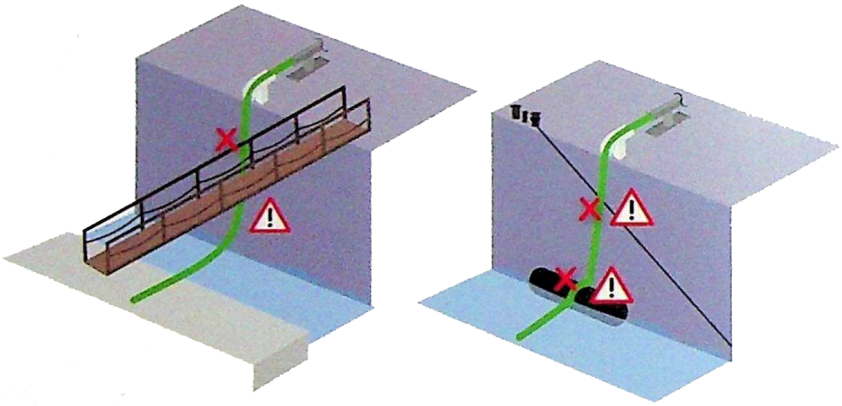
Notes:
"Calculations based on loading" is used as a general term to define numerical and software-based estimation methods. "Tank sounding" is used as a general term, but it may be measured on board by different means, with most vessels using radar or laser readings.

4.9 Access and Mooring

As part of the initial design of any vessel, mooring arrangements and access points such as gangways and ramps are considered, based on the type of vessel and its intended operations. Additional considerations and requirements for gas-fuelled vessels that will bunker LNG are outlined below:

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner, operator and designers • Bunkering facility: owner, operator and designers

Figure 4.11: Examples of potential hose obstructions during operations



Considerations and recommendations

1. **Access** to the gas-fuelled vessel during LNG bunkering should take into account the implications of interfering with or obstructing hose bunker system operations (see Figure 4.11) and the potential risk of overlapping the hazardous and safety zones.
   a. consideration should be given to access to the gas-fuelled vessel by the crew, other personnel, passengers and cargo
   b. access gangways and ramps used for personnel, passengers or goods should be located away from the bunker station

c. during the design stage it is advisable to discuss and define the boundaries of the safety zone to check whether access points might fall in between, limiting or preventing their use during bunkering
d. consideration should also be given to contact-free ship-to-ship bunkering, in which no personnel access is required between vessels

2. **Mooring** – When ship-to-ship LNG bunkering is envisaged, the gas-fuelled vessel designer should consider the following – including the number of bollards, and their locations and capacities – when designing mooring arrangements:
   a. because most existing LBVs are designed for international voyages, they have larger storage volumes than traditional fuel oil bunker barges and are therefore larger in size (see Lessons Learned 4-6 LNG Bunker Vessel (LBV) Particulars, on page 79)
   b. ship-to-ship bunkering may be conducted in port alongside a quay or in open water at anchor. Overall bunkering duration is also typically longer than a traditional oil bunker – a typical ship-to-ship bunkering operation of 1,000 m^3 transferred via a single 6" bunker hose might take 3-5 hours from when mooring or securing of the vessels is completed
   c. mooring lines should not cross the path of the bunker transfer system connecting to the gas-fuelled vessel bunker station (see Figure 4.11)
   d. to accommodate the slack hose catenary, in most cases large pneumatic fenders are positioned between an LBV and a gas-fuelled vessel. These may have a diameter of more than 2.5 metres
   e. it is advisable during the design of a gas-fuelled vessel to consider additional mooring points near the bunker station and sufficient flat side fore and aft of the manifold for fender placement

Lessons Learned 4-6: *LNG Bunker Vessel (LBV) Particulars*

The following information on a range of LNG bunker vessels should be considered typical and approximate, and used only for educational/ informative purposes.

Wherever possible, designers are invited to validate their assumptions of LNG bunker vessel particulars with their preferred or designated supplier.

Table 4.4 Approximate LBV Particulars

Approximate LBV Particulars Data source: SGMF bunker vessel data base – May 2021 (educational/informative purposes only)					
Tank size / type [m³]	**Vessel Type**	**LOA[m]**	**Breadth [m]**	**Draft [m]**	**Dead-weight [tonne]**
1,500 -C-	Harbour barge – pontoon	75	12	TBC	700
3,000 -C-	Harbour barge – pontoon	110	15	2.8	TBC
1,000 -C-	Sea-going gas tanker	70	12	4	800
6,000 -C-	Sea-going gas tanker	100	18	5.8	3,100
7,500 -C-	Sea-going gas tanker	115	18.5	6.8	6,000
10,000 -C-	Sea-going gas tanker	140	20	7.5	10,400
18,500 -Mem-	Sea-going gas tanker	135	24.5	6.8	9,500

-C- : Type C tank -Mem- : Membrane Tank TBC : to be confirmed

Figure 4.12: An example of ship-to-ship mooring (Picture courtesy of Aida, Anthony Veder and Shell)

4.10 Hazardous Area and Safety Zone

Hazardous areas and safety zones are three-dimensional spaces located around the supplier, the bunker transfer system and receiving equipment such as manifolds and vents, where there is a potential risk of release of gas, as defined in Section 3.3.

Their presence and boundaries impact the design of both the bunkering facility and the gas-fuelled vessel and they should therefore be considered at this stage.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner, operator and designers • Bunkering facility: owner, operator and designers • Terminal/port authority (shore bunkering facility)

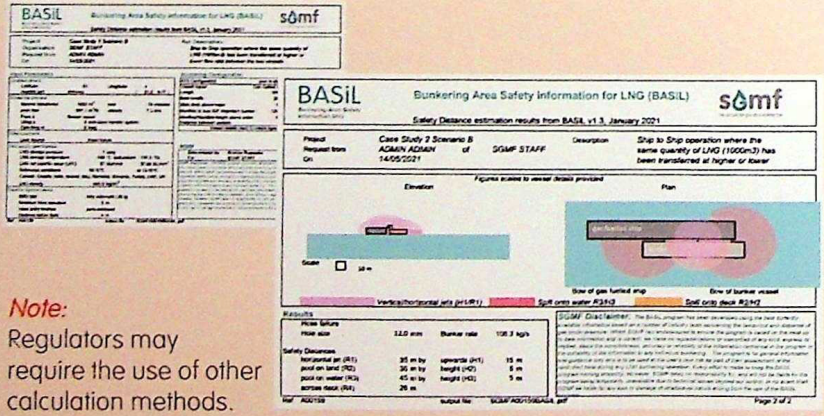
Note:
Owners, operators and designers should refer to the SGMF publication *Recommendation of Controlled Zones During LNG Bunkering – FP02-01 Ver1.0* for specific guidance on the definitions and requirements of hazardous and safety zones.

Considerations and recommendations

1. In accordance with statutory regulations and codes, hazardous zones associated with the fuel gas system and the bunkering installation – Zones 0, 1 and 2 – need to be defined during the design of the bunkering facility and the gas-fuelled vessel, with the objective of the classification "to allow the selection of electrical apparatus able to be operated safely in these areas".
   a. hazardous zones around the receiving vessel manifold flanges, valves and vents are defined by the IGF Code (Ref: IGF Code, § 12.4 and § 12.5)
   b. hazardous zones around the bunkering facility manifold flanges, valves and vents are defined by national or international regulations or the IGC Code for bunker vessels
2. A hazardous area plan should be developed by the bunkering facility and the gas-fuelled vessel, indicating all Zone 0, 1 and 2 spaces.

3. If the bunkering scenario is known, consideration should be given to the existence of any hazardous areas associated with the supplier or receiver and how these may overlap. Attention should be directed at the hazardous zone around vents, vent masts and air intakes for ventilation. These can be larger zones and their boundaries may overlap the other party's structure. For example, a bunker vessel's vent mast hazardous zone may reach over the deck of the receiving vessel where operations are carried out or passengers are present, or a gas-fuelled vessel's vent mast hazardous zone may impact the operation of a loading crane in a terminal.
4. A safety zone is required around the bunker station, in addition to the hazardous zones, due to the potential risks of accidental releases of gas during bunkering. The safety zone is a temporary and larger zone than the hazardous zones and only relevant during bunkering operations. There is no statutory requirement to define the safety zone during the design stage of the bunkering facility or the gas-fuelled vessel. However, safety zones and their boundaries impact the type of operations that can be carried out around the bunker station and during bunker operations.

Note:
Owners, operators and designers may use **BASiL** – the SGMF's automated "Bunkering Area Safety Information for LNG" model – as an aid in defining a safety zone that depends on the type of bunkering operation being undertaken.



Note:
Regulators may require the use of other calculation methods.

4.11 Bunkering Design Risk Assessment – Design Mitigations

While experience in the design and operation of LNG bunkering installations is available and requirements are included in regulations, codes, and additional industry guidance (see Section 3.5), performing a risk assessment of the bunkering operation in the early design stage of a bunkering facility or gas-fuelled vessel can provide specific design recommendations, which, if considered at this stage, may mitigate the costs of having to make modifications later during construction or after the build.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner, operator and designers • Bunkering facility: owner, operator and designers

Considerations and recommendations

1. During the design stage of the bunkering facility and the gas-fuelled vessel, the bunkering operation, the bunkering supply scenario, and the bunker transfer system should be subjected to a risk assessment. It is advised that a design bunkering risk assessment is undertaken with representatives from the builders, fuel gas system provider, owner and class representatives during the design stage of the asset.
2. This risk assessment should be used to identify additional and vessel-specific mitigations, taking into account the ship's design and the owners' requirements. These mitigations can be design-based or procedural via the operating and maintenance procedures.
3. Owners, operators and designers should refer to: the additional guidance for risk assessment, including SIMOPs, provided in Chapter 9 of this document; ISO 18683; and the SGMF publication Simultaneous Operations (SIMOPs) during LNG Bunkering – FP08 – 01 Ver1.0.

4.12 Design for Bunkering Compatibility

Great emphasis should be put by the bunkering facility and the gas-fuelled vessel owners, operators and designers on compatibility at each stage of the bunkering process.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner, operator and designers • Bunkering facility: owner, operator and designers

Considerations and recommendations

1. Bunkering compatibility should be one of the main objectives of designers of bunkering equipment and interfaces. LNG bunkering suppliers tend to put a lot of effort into designing their systems and equipment to be compatible with a large number of receiving vessels and configurations. However, gas-fuelled vessel designers should also ensure they follow industry guidelines and good practice during the vessel design stage to avoid costly compatibility issues during operations (see Lessons Learned 4-7 GFV Design – Compatibility, Common Issues and Good Practice, on page 86).
2. Because LNG bunkering is still relatively novel and experience still limited, a high-level design-stage bunkering compatibility study should be undertaken by the gas-fuelled vessel.
   a. the compatibility review should be used to confirm that the bunker station design, arrangements and location will allow bunkering in line with operational requirements such as location, duration and SIMOPs
   b. a design compatibility review is particularly advised where the intention is to bunker from the shore side while undertaking SIMOPs
   c. where the primary or potential bunkering supply scenario includes ship-to-ship as part of the design compatibility, a review should be undertaken of the necessary mooring arrangements to ensure an LNG bunker vessel can moor safely; additional mooring arrangements may be required near the LNG bunker station
3. Items to be considered in the design compatibility study include:
   a. manifold arrangements:
      i. distancing, spacing, orientation and strength

ii. layout, instrumentation and connections

b. bunker station location versus:
   i. parallel body
   ii. mooring arrangements
   iii. vessel access points and gangway
   iv. hazardous area (inboard and outboard potential overlaps)
   v. safety zone (inboard and outboard potential overlaps)

c. fixed lifting appliances:
   i. Safe Working Load (SWL), reach and location

d. bunkering safety link:
   i. technology selection
   ii. primary and back-up requirements

e. electrical isolation method:
   i. insulation flanges
   ii. grounding/bonding

f. mooring arrangements:
   i. ship-to-ship and shore-to-ship operations
   ii. mooring loads and points location

g. Capacity to manage or consume bunkering boil-off gas (BOG):
   i. vapour return connection
   ii. tank(s) holding capability
   iii. a secondary means of managing tank pressure and temperature

Note:
Owners, operators and designers may use the SGMF's *GFV-A, Gas-Fuelled Vessel LNG Bunker Station Manifolds Arrangement Information Form* as an aid to exchange with third parties the particulars of the manifold arrangement and bunker station location so that compatibility can be assessed.

Lessons Learned 4-7: *GFV Design – Compatibility: Common Issues and Good Practice*

The following list is a collection of common issues and challenges observed in early designs of gas-fuelled vessels.

1. **The absence of a "top-filling line" in some tank designs, particularly for pressurised tanks.** While all tanks have a spray line, designed for cooling down, and a bottom-filling line, some do not have a top-filling line. A top-filling line typically has much larger injection holes than a spray line dimensioned for a proportionate loading flow rate. Absence of a top-filling line can lead to overall reduced loading flow rate or require a vapour-return line during bunkering to control BOG. Use of a top spray line during bunkering is an effective means of managing tank pressure by the gas-fuelled vessel.
2. **Bunker station designs that do not follow SGMF recommendations are often too small or ergonomically unsuitable and unsafe for personnel**. A bunker station should have enough space to accommodate two crew members, preferably one each side of the manifold, and be designed with ergonomics in mind (ref: TGN06-04, Ver1.0 § 3.6 and 3.7).
3. **Bunker manifold presentation flange too close to the side of the ship.** This is a common issue. SGMF manifold recommendations give guidance on manifold presentation flange setback. Failure to comply can exacerbate risks to personnel during connection, and can lead to longer connection times and leakage due to inadequate hose support (ref: TGN06-04, Ver 1.0 § 3.2).
4. **The bunker manifold arrangement should include:**
   a. a pressure-relief valve (PRV) installed between the first isolation valve and the manifold presentation flange:
      i. The designer should consider all parts of the bunkering system and all scenarios that could result in LNG becoming trapped. This may include special consideration for the potential of liquid or vapour trapped between the first isolation valve and the ERC, in the dry-disconnect/connect coupling, or in other parts of the transfer system. Where the gas-fuelled vessel is expected to bunker from unknown bunker facilities, it is suggested that a hose length of at least 10 metres of the same diameter as the liquid bunkering line is considered in trapped-volume calculations (ref: TGN06-04 Ver1.0 § 6.2).

ii. The designer should consider the risk of a PRV seizing due to frost condensation after initial release. PRVs should be installed after a suitable extension is provided from the main line. An additional back-up PRV should also be considered in some applications or an alternative means of allowing pressure to be drained safely back to the LNG tank through the piping system.

b. a sampling point between the first isolation valve and the manifold presentation flange. This may be achieved by a double block to the vent mast and bleed valve to an open sampling point or other arrangements providing the same type of safety and functionality. The provision of double isolation is recommended for all connections onto the main bunkering line. (Ref: TGN06-04, Ver1.0 § 2.6 and 6.3):
   i. The sampling point must be located on the upper part of liquid lines.
   ii. Wherever possible, sampling points should not be oriented toward operators and should not be used for temporary nitrogen supply connections.

5. **To monitor and mitigate fugitive emissions, gas sensing should be included in the vent mast for the tank relief valve and the various reliefs and vents from the LNG and gas systems throughout the vessel.** In some applications, these sensors have proven invaluable in detecting anomalous gas relief or venting.
6. **Liquid and vapour manifold spacing should allow sufficient space for the use and connection of ISO standard dry disconnect/connect couplers (DD/CCs) or couplers of other types.** (Ref: TGN06-04, Ver1.0 § 3.2)
7. **Bunker stations, especially enclosed or semi-enclosed, with unsuitable lifting gear and anchor points.** Bunkering equipment, hoses, connectors and ERCs are heavy and difficult to manoeuvre into position. Lifting gear and suitably located anchor points are essential for all bunkering operations. (Ref: TGN06-06, Ver1.0 § 5.1)
8. **Inadequate communication to and from the gas-fuelled vessel.**
   a. the gas-fuelled vessel should consider adding a fixed VHF radio in the engine control room
   b. it is advisable is to have a VHF station with antenna in the ship's mast or an equivalent means of communication
   c. care should be taken to avoid radio channels used by other ships in the port or its vicinity to prevent interference with bunkering communications. This could give the ship staff/bunkering team the impression that an incorrect task/activity is being performed, resulting in undesirable situations

9. **For hose-based transfer systems, hose support is required on the receiving vessel.** A common support mechanism is to use hose saddles, and these should be properly positioned and dimensioned:
   a. if self-standing hose saddles are used, these need space on the manifold platform, thereby reducing the space available for the connection, which should be considered on the presentation flange setback requirements
   b. hose saddles can be a semi-permanent part of the bunker station structure, but these should be removable in case operations require it
   c. saddle placement and height should account for straight alignment to the presentation flange and the hose bend radius
   d. handrails are not suitable hose saddles
10. **Water curtains are often not sufficient or are improperly designed and positioned, creating an impediment to the bunkering operation.** They should be part of the design of the bunker station. Retrofitted hoses and piping located in a haphazard way on the manifold area are not a suitable solution.
11. **The testing point of local gas detection sensors in the bunker station permanent hazardous area should be located outside such an area to facilitate regular testing and calibration.** Designers and builders should consider how sensors can be accessed in situ, particularly when they are installed in a permanent hazardous area, so that they can be surveyed and tested.
12. **Absence of mooring points on the GFV for ship-to-ship bunkering is often an issue.** This can lead to longer than necessary mooring operations.
13. **A bunker station located below or close to personnel or passengers gangway or access ramps.** During LNG bunkering, such gangways and ramps may fall within the safety zone, limiting or preventing their use.
14. **Non-conforming, low-cost solutions or a lack of a standard bunkering safety link (BSL) for ESD being installed.** Recommendations for BSL types and functionality provided in SGMF guidelines should be followed to ensure safe operation and compatibility (ref: TGN06-05, Ver1.0). Special consideration should be given to:
   a. pneumatic BSL system, operating pressure and lay-out/schematic
   b. 5-Pin BSL System, pin configuration and connector (some vendor systems may require an adaptor link for compatibility)
   c. fibre-optic BSL system, ESD and data signal compatibility

15. **In case of an ESD-2 event, the hose or part of the hose may remain with the receiving vessel.** Manifold strength and PRV should be dimensioned for such an eventuality (ref: TGN06-04, Ver 1.0 § 5.5 and 6.2).
16. **A bunker manifold designed without PRV, sampling point, nitrogen supply and so on.** The SGMF provides recommendations on the layout of the bunker manifold and instrumentation and inlet/outlet connections. Failure to provide such connections can lead to delays, or gas emissions during disconnection (ref: TGN06-04, Ver 1.0 § 2.6).
17. **Filters and strainers at the bunker manifold not being installed or incorrectly specified.** These can potentially allow impurities to enter the gas-fuelled vessel fuel systems, creating potential problems for equipment and operations. The SGMF provides recommendations on filters and strainers in its guidelines (ref: TGN06-04, Ver 1.0 § 6.4).
18. **Presentation flanges of non-standard ratings may prevent connection and bunkering or the use of a QC/DC.** SGMF recommends the ASME B16.5 Class 150 lbs flange as the standard presentation flange; further sizes and ratings are available in its guidelines (ref: TGN06-04, Ver 1.0 § 5.1-5.4).
19. **Bunker manifolds and their inlet connections, PRVs, sampling points, nitrogen supply and so on should be suitably designed to prevent ice build-up due to the cryogenic temperatures of LNG.** Moreover, external atmospheric moisture should not impede their operation.
20. **Final as-built manifold configurations, dimensions, PRVs, flange sizes and ratings that differ from design drawings can delay operations or inhibit bunkering.** Vessel operators need to confirm that all as-built information is true and valid as per the design documentation and drawings to facilitate compatibility checks with a range of bunker vessels.
21. **GFV capability and a means to manage boil-off gas during bunkering operations should be considered during the design stage.** Designers should consider bunkering supply scenarios with and without the use of vapour return and include in their assessment the typical excess BOG generated during bunkering operations. This may require the installation on board of a secondary means of managing the pressure and temperature of tank(s) (ref: IGF Code § 6.9.1).

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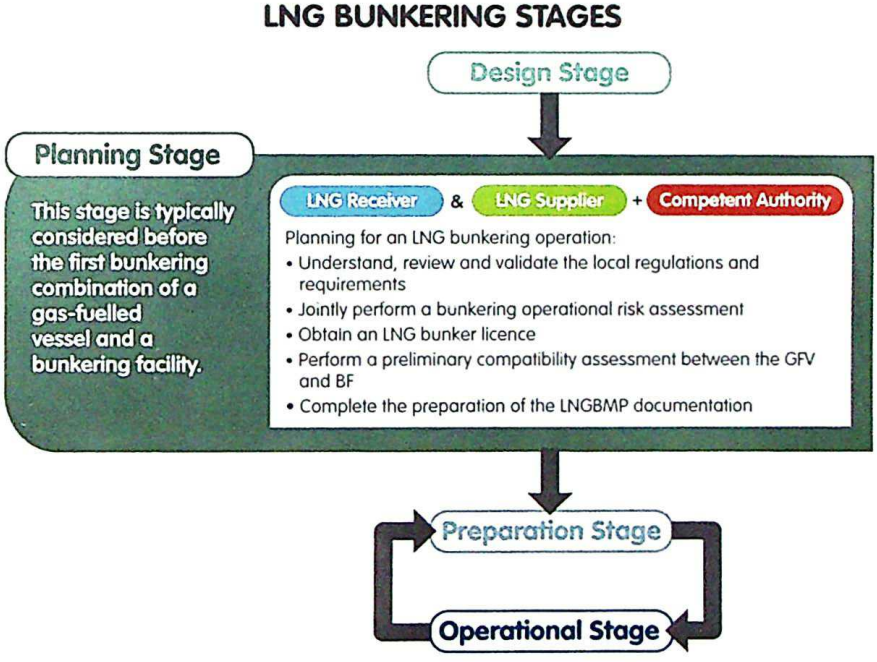
5. Planning Stage – LNG Bunkering

5.1 General

When:
The **Planning stage** spans from the construction of the bunkering facility and the gas-fuelled vessel through to commissioning and delivery.

It is also repeated when a new, different bunkering need is identified. This may be due to a change in bunkering location or supply scenario, or when a new operation is envisaged between a bunkering facility and a gas-fuelled vessel which has never been conducted before.



Who:
This stage is led by the owners and operators of the bunkering facility and the gas-fuelled vessel. Additionally, the competent authority(ies), regulators and administrations with jurisdiction over, or an interest in, the bunkering operations may be incrementally engaged in the planning of operations for a specific location or area for the purpose of audit, bunkering licensing or enforcement.

While different stakeholders may conduct this stage partially independently from each other, it is likely that the exchange of information and collaboration between the parties will become more frequent over the duration of the planning stage.

Goals:
During the planning stage, the primary objective is to identify and understand any potential barriers and showstoppers to future bunkering operations and to outline the operational, technical, safety and training requirements and response actions needed to satisfy all stakeholders.

Furthermore, at the planning stage, a bunkering licence might be awarded for a new bunkering installation/operation or conformance confirmed to an existing licence which might include exclusions for specific operations.

1. **Understand and fulfil local requirements**
   a. to identify the requirements set by national or local legislation that apply to the intended bunkering area
   b. direct liaison between the receiver, the supplier and the national body and competent authority(ies) with jurisdiction over the bunkering location to fulfil local requirements and obtain the necessary approvals or licences for planned bunkering operations
2. **Understand operational barriers**
   a. to identify barriers and challenges to future operations that may impact safety or compatibility between supplier and receiver
   b. to identify and communicate with all stakeholders who may be involved or impacted by the LNG bunkering operation
3. **Outline operational requirements**
   a. to identify stakeholders' technical, safety and training requirements and to plan response actions
   b. to focus on the planning activities that should be undertaken in advance of LNG bunkering and to provide guidance for shipowners and operators of gas-fuelled vessels, LNG suppliers, terminal owners and operators, and port authorities which have future operations within their jurisdiction

5.2 Key Roles and Responsibilities (Planning)

Table 5.1 below summarises the key roles and responsibilities of stakeholders who may be involved in the planning stage of a bunkering operation (see Section 3.2):

Table 5.1: Planning stage – stakeholders' key roles and responsibilities

Planning stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
LNG receiver (the gas-fuelled vessel owner and/or operator)	• Defines the bunkering operational requirements for the gas-fuelled vessel. • Carries out a risk assessment of the bunkering operation in collaboration with other stakeholders. • Shows conforming to licence terms.	Maximise flexibility in utilising a range of bunkering facilities for supply.
LNG supplier (the bunkering facility owner and/or operator)	• Defines the bunkering operational requirements for the bunkering facility. • Carries out a risk assessment of the bunkering operation in collaboration with other stakeholders. • Shows conforming to licence terms.	Maximise flexibility in delivering to a range of gas-fuelled vessel types.
Designer(s) (including facility, vessel(s) equipment designers, as applicable)	• Likely to be consulted when the gas-fuelled vessel or bunkering facility is under construction. • May be consulted when additional detail or evidence is required for compatibility.	Not involved unless design changes are required May provide technical support to supplier/receiver
Regulator [1] (typically a national body with jurisdiction over the bunkering location; this can sometimes be the port authority)	• Should define the risk assessment criteria for the bunkering operation. • May take part in the bunkering risk assessment. • Review design, risk and corporate governance information and decide whether to award a bunkering licence.	

Planning stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
Port authority [1] [2]	• Actively involved in the risk assessment of the bunkering operation under its jurisdiction. • Carries out or oversees the preparation of bunkering location/ area. • Reviews and approves the bunkering operation and the parties involved.	
Terminal operator [2]	• Actively involved in the risk assessment of the bunkering operation under its jurisdiction, especially if SIMOPs are expected at the terminal. • Carries out or oversees the preparation of the bunkering location/area.	Depending on the intended location (when known), which may involve installations or activities onshore.
Emergency services [2]	• May be involved in the risk assessment or reviewing of the bunkering operation.	Depending on the intended location (when known), which may involve installations or activities onshore.
Port users [2]	• May be consulted.	Depending on the intended location (when known), which may involve installations or activities onshore or restrictions on passing vessels.
Neighbouring facilities and the public [2]	• May be consulted.	Depending on the intended location (when known), which may impact installations or activities onshore and/or in public areas.

Notes:

[1] Regulators and the port authority may in some cases have interchangeable roles.

[2] This stakeholder may be involved when the bunkering activity falls within the boundaries of a port or area of jurisdiction/interest.

5.3 Key Activities and Considerations

Special considerations are needed during the planning stage of LNG bunkering. These are discussed in the following sections, which provide specific recommendations and considerations by bunkering supply scenario and are based on industry experience and good practice.

Key considerations for the **Planning stage** of LNG bunkering discussed in the following chapters include:

- bunkering supply scenario and location
- location planning
- risk assessment and safety zones
- SIMOPs assessment
- training planning and implementation
- emergency response planning
- preliminary compatibility assessment

Note:
LNG bunkering stakeholders should recognise that the key considerations discussed above:

a. do not have an obvious hierarchy as to which is more important. Some assets, configurations and scenarios will be more sensitive or impacted than others
b. are strongly interlinked and must be reviewed as part of an iterative process
c. are typical and general, and do not constitute an exhaustive list. Specific designs, installations, locations and operations may require considerations above and beyond those discussed in this chapter

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5.4 Bunkering Supply Scenario and Location

A key activity of the planning stage is to define the gas-fuelled vessel bunkering supply scenario:

- ship-to-ship, shore-to-ship or mobile-to-ship
- the intended location or area
- general boundary conditions

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator *with the involvement of* • Regulator/port authority/terminal operator

The following considerations and recommendations are advised to identify and collect sufficient information regarding the future LNG bunkering operation and to provide an early understanding of any potential barriers or showstoppers.

Considerations and recommendations
At this stage, the LNG bunkering stakeholders should aim to identify and broadly define:

1. The type of gas-fuelled vessel that will be bunkered, including its particulars and the overall design of the gas-fuelled system.
2. The bunkering facility design and arrangement:
   a. ship-to-ship: LBV particulars, and the overall design of the LNG supply system
   b. shore-to-ship: refuelling terminal particulars, and the overall design of the LNG supply system
   c. mobile-to-ship: truck or container numbers, and the overall design of the LNG supply system
3. The type of LNG bunkering system: hoses, loading arm or hybrid.
4. The bunkering location:
   a. shore-to-ship and mobile-to-ship: port/terminal quayside location, including boundaries
   b. ship-to-ship: alongside a berth or offshore

5. All local bunkering stakeholders. When the bunkering location is identified, the supplier and receiver – in consultation with the regulator, port authority and terminal – should aim to map all local bunkering stakeholders, as discussed in Section 3.2, particularly: emergency services, port users, neighbouring facilities and the public.
   a. Some ports may define where LNG bunkering can take place, this might be referred to as a port bunkering LNG map. In these locations the port has already concluded that bunkering is acceptable. Extensive consultations would therefore not then be needed.

5.5 Location Planning

A bunkering location should be identified during the planning stage. The proposed location will fall within the remit and jurisdiction of a national and/or local authority, so before any operation can go ahead the acting LNG bunkering organisation and the receiving ship operator (see Section 3.2.2) should be authorised/accredited/licensed by the competent authority with jurisdiction, once they have demonstrated they are compliant and prepared.

Key activity stakeholders (see Section 3.2)	
Who:	• Regulator/port authority/terminal operator *with the involvement of* • Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator

Considerations and recommendations

1. The competent authority, port authority and/or national or other authority with jurisdiction over the bunkering operation should consider existing regulations or, if required, the development of specific local regulations, to assess the safety and suitability of a proposed location for LNG bunkering.
2. The safety and suitability assessment of a bunkering location by the relevant authorities should consider:
   a. identifying applicable national risk acceptance criteria or agreeing criteria to be used for risk studies

b. an accreditation, licensing and authorisation scheme for the LNG bunkering organisation and the receiving ship operator within their jurisdiction, including:
   i. establishing auditing and inspection requirements and processes
   ii. a process to ensure there is a clearly defined structure showing the division of roles and responsibilities between the involved parties and identifying key personnel
   iii. required corporate behaviours and governance structures
c. identifying location-specific operations which may be restricted or which may impact bunkering operations – for example, port SIMOPs
d. criteria and processes for the acceptability of the location of bunkering facilities and operations (bunkering may be limited to specific locations within the port/anchorage)
e. a process for the implementation of governance and a framework for LNG bunkering operations in the port. This should include:
   i. an enforcement system by LNG-trained officers
   ii. general procedures for traffic control, passing traffic and restrictions
   iii. shore-side contingency plans and emergency response systems
   iv. identification of LNG-trained and LNG-prepared emergency response organisations

3. Decisions and requirements for LNG bunkering should be based on a risk analysis carried out in advance of any bunkering operation.

Note:
The competent authority, port authority and/or national or other authority with jurisdiction over the bunkering operation may refer to the European Maritime Safety Agency (EMSA) publication *Guidance on LNG Bunkering to Port Authorities and Administrations* – or equivalent for the geographical area of interest – for specific guidance on the LNG bunkering, assessment and approval licensing process.

5.6 Bunkering Operational Risk Assessment

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator *with the involvement of* • Regulator/port authority/terminal operator

5.6.1 Risk assessment

Risk assessment plays a vital role in LNG bunkering to establish that a design and its operations are safe and to identify any mitigations required. So, once the bunkering supply scenario, method, means and area/location have been established, a bunkering operational risk assessment should be undertaken in collaboration with the appropriate stakeholders. Guidance on undertaking risk assessments is detailed in Chapter 9.

5.6.2 Safety zones

The safety zone is an area where gas could be present following a leak during bunkering. It is additional to any hazardous areas, as defined in Section 3.3. Only in force during bunkering, it is an area where special precautions are needed to limit access, ignition sources and any other potentially hazardous events.

While the safety zone has already been discussed during the design stage (see Section 4.10), during the planning stage the focus is to understand how the extent and boundaries of the zone impact operations between a specific bunkering facility and a specific gas-fuelled vessel.

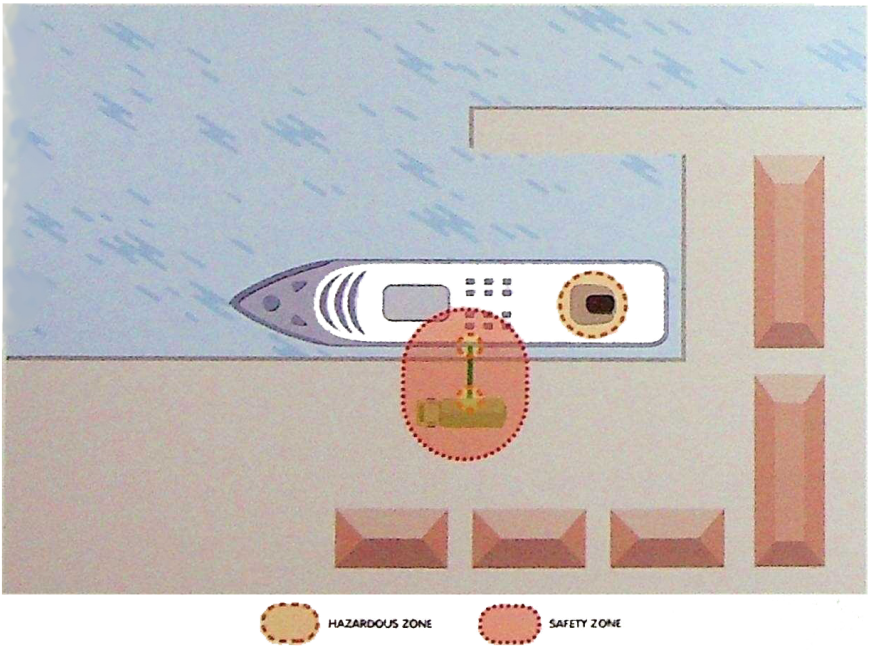
Considerations and recommendations

1. The safety zone should be calculated at the planning stage considering and using:
   a. the general boundary conditions identified in Section 5.4 – for example, bunkering supply scenarios, bunker system type, bunker process particulars, location environmental data and so on

b. a suitable methodology or tool – for example, Quantitative Risk Assessment, computational fluid dynamics (CFD) analysis, modelling tools such as SGMF's BASiL model and so on
c. a representative leak scenario. More guidance and a detailed methodology is available in the SGMF publication *Recommendation of Controlled Zones During LNG Bunkering – FP02-01, Ver1.0*

2. The potential overlaps between the bunkering safety zone and the gas-fuelled vessel and bunkering facility should be clearly identified and marked.
3. Safety zone extension and boundaries should be considered and reviewed during the risk assessment discussions (see Section 5.6.1) and SIMOPs discussions (see Section 5.7) to identify any risk in-between the safety zone and associated mitigations.

Figure 5.1: An example of hazardous zones and safety zone during LNG bunkering



5.7 SIMOPs Assessment

SIMultaneous OPerations (SIMOPs) are defined in this document as "LNG bunkering plus one, or more, other independent operations conducted together within the control of the PIC(s), where the operations may impact, or increase the impacts on personnel safety, ship integrity and/or the environment".

For a large proportion of gas-fuelled vessel owners, the ability to undertake LNG bunkering at the same time as cargo or passenger operations (SIMOPs) is essential, especially if this is the current method for conventional fuel bunkering.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator *with the involvement of* • Regulator/port authority/terminal operator

Considerations and recommendations

1. SIMOPs can add additional hazards, particularly:
   a. ignition sources outside those associated with the bunkering operation itself
   b. additional consequences – for example, the presence of more people in the vicinity
2. The SIMOPs assessment should be based on the:
   a. output from the operational risk assessment (see Section 5.6.1)
   b. the safety zone extension and boundaries calculated at this stage (see Section 5.6.2)
3. It is recommended that the SIMOPs assessment is undertaken in a formal way and documented accordingly.
   a. a typical SIMOPs assessment should:
      i. determine/identify "likely or normal" SIMOPs
      ii. assess the risks associated with SIMOPs
      iii. determine whether additional risk mitigations are required
   b. mitigations, technical, procedural or both, can be used to improve the potential SIMOPs through co-ordination between the port authority, terminal operator, bunkering facility and gas-fuelled vessel

c. the SIMOPs assessment or output should be recorded in such a way that both supplier and receiver have visibility of approved operations and any risk mitigations required
d. the SIMOPs assessment should not only consider the impact of operations within the remits of the bunkering facility and gas-fuelled vessel but also the wider operations of the port and/or terminal, on the shore and on the harbour, as applicable

Note:
Owners, operators, and designers should refer to the SGMF publication *FP08-01 Simultaneous Operations (SIMOPs) during LNG bunkering* for specific guidance on SIMOPS definition, assessment process, mitigation and requirements.

Figure 5.2: An example of LNG bunkering and SIMOPs operations at a container terminal (Picture courtesy of FueLNG, CMA CGM and Shell)

5.8 Training Planning and Implementation

Any parties involved with the use and handling of LNG should provide their personnel with appropriate and adequate training for:

- the operations to be carried out
- the equipment to be used

There should be a system in place to review and maintain training over time.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator • Regulator/port authority/terminal operator *with the involvement of* • Emergency services

Considerations and recommendations

1. During the planning stage, the training requirements of the parties involved should be reviewed against international, national and local regulations, actual operational requirements and the requirements of stakeholders:
   a. if LNG bunkering personnel are not properly trained, operations should not start
   b. national and local training regulations and requirements can vary significantly from region to region so it is advisable to review the training provided to local personnel
   c. marine training in accordance with STCW should be complemented by/integrated with additional training to provide competence for bunkering system operators.
2. While personnel training should always comply with the applicable statutory requirements, all the parties involved have an additional duty and responsibility to identify and implement any specific and additional training that may be required for their operations.
3. Personnel training documentation should be available for inspection and auditing

4. Additional and specific LNG bunkering training should be provided to the personnel involved in the bunkering operation:
   a. LNG bunkering poses additional risks since multiple parties are simultaneously involved. Training should therefore include an understanding of the division of roles and responsibilities of the various parties involved and their interactions
   b. LNG bunkering operations vary depending on location and bunkering supply scenario – for example, a gas-fuelled vessel may be bunkered by a bunker vessel on one day and by a truck on another. Personnel should therefore be suitably trained for all foreseeable types of bunkering operations
5. All parties involved in LNG bunkering are responsible for training, as follows:
   a. the gas-fuelled vessel is responsible for the training of the personnel of the receiving ship operator, including emergency response personnel
   b. the bunkering facility is responsible for the training of the LNG bunkering organisation personnel, including emergency response personnel
   c. the port authority/terminal is responsible for the training of personnel interacting with a gas-fuelled vessel and/or a bunkering facility during bunkering operations
   d. any authority with jurisdiction over the bunkering area/location is responsible for the training of emergency response services, including firefighters and medics

Note:
Training requirements and personnel competence for LNG bunkering are not discussed in detail in this publication. Receiver and supplier owners, operators and regulators, port authorities and terminal operators should refer to the SGMF publication *Bunkering of ships with Liquefied Natural Gas (LNG) competency and assessment guidelines – FP04-02* for specific guidance on competence and training for personnel involved in bunkering.

Figure 5.3: Example of a shore-based bunkering facility
(Picture courtesy of Harvey Gulf International Marine)

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5.9 Emergency Response Planning

An Emergency Response Plan should be prepared to contain, control and end any emergency that may arise during LNG bunkering operations. It should address hazards and emergency response activities, including managing gas or liquids leak and any, if ignited, subsequent fires.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator • Port authority/terminal operator *with the involvement of* • Emergency services

Considerations and recommendations

1. The gas-fuelled vessel, the bunkering facility and the port authority and terminal operator, in collaboration with local emergency services, are responsible for preparing their own emergency response plans, taking into consideration the operation to be conducted, specific and local risks, and requirements and regulations.
   a. the gas-fuelled vessel, bunkering facility and terminal are responsible for any initial emergency response. The port authority may provide personnel and equipment to support/replace the first responders or may rely on external community emergency response.
   b. External community response will be required if the incident goes beyond port boundaries.
2. The emergency response plan should cover all emergency situations identified in the LNG bunkering risk assessment (see Section 5.6), in addition to any requirements set by authorities with jurisdiction over the bunkering location or operation, such as regulators and port authorities.
   a. as a minimum, the following situations should be covered, where appropriate:
      i. LNG leakage and spill on the receiving ship, on the bunkering facility or from the LNG transfer system
      ii. gas detection
      iii. fire
      iv. unexpected movement of the vessel due to failure or loosening of mooring lines if applicable

v. unexpected movement of the truck tanker if applicable
vi. unexpected discharge on the venting on the receiving ship or on the bunkering facility
vii. loss of power
viii. personnel injury (from cold and/or asphyxia)
ix. collision with a passing vessel

b. as a minimum, the emergency response plan should include, where appropriate:
i. emergency response procedures
ii. emergency resources
iii. emergency communication system(s) and contact details
iv. emergency management and communication system(s) and contact details including procedure on how to escalate to other better resourced authorities.
v. emergency services coordination and roles (as applicable)
vi. public emergency response (as applicable)

c. Emergency response plans should be periodically tested by drills to reinforce training and retain competence

5.10 Preliminary Compatibility Assessment

A preliminary bunkering compatibility assessment of the bunkering facility and gas-fuelled vessel should be undertaken during planning to identify any aspects that require management.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator

Considerations and recommendations

1. The preliminary compatibility assessment may occur before the receiving vessel or bunkering facility are delivered. The supplier and receiver should therefore use the best available information, which will be further validated during the detailed compatibility assessment in the next phase (see Section 6.9).
2. The overall objectives of the preliminary compatibility assessment are to validate the general boundary conditions and barriers, and issue any

recommendations to be considered at the preparation stage, when bunkering equipment and interfaces are prepared.

3. The preliminary compatibility assessment may be undertaken with the assistance of a suitable checklist, and the outcome and recommendations should be recorded in a report (see Section 3.7).
4. Owners and operators of gas-fuelled vessels and bunkering facilities should develop their own procedures to validate compatibility between supplier and receiver:
   a. these may vary, depending on the type of bunkering scenario, system configurations and layout
   b. this publication offers a high-level methodology in Lessons Learned 6-3: A Methodology for Preliminary and Detailed Compatibility Assessment that may be followed and tailored to support supplier and receiver in this exercise

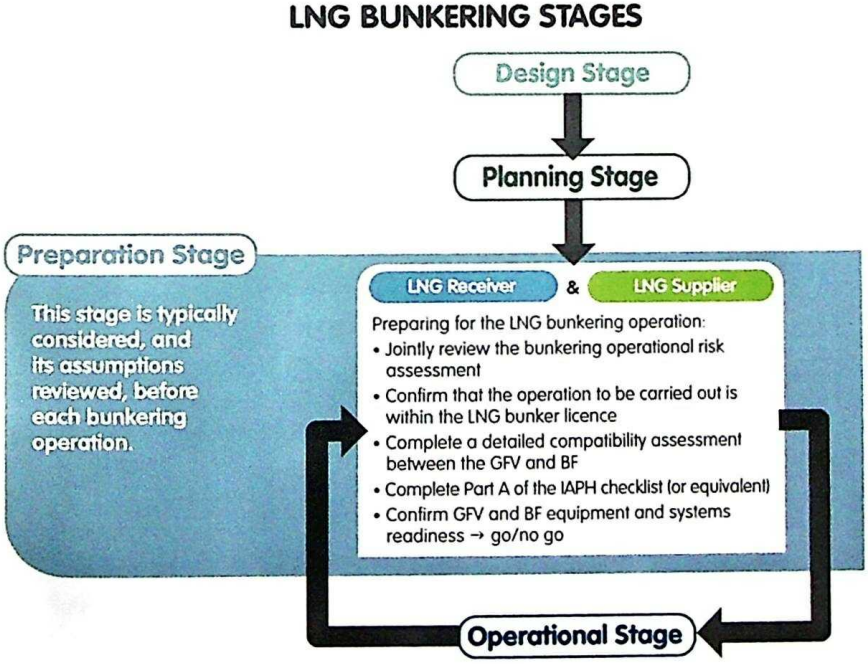
6. Preparation Stage – LNG Bunkering

6.1 General

When:
The **Preparation Stage** spans from the commissioning of the supply bunkering facility (BF) and the gas-fuelled vessel through to the first ever bunkering operation.

It is reiterated when a new, different bunkering need is identified. This may be due to a change in the bunkering location and supply scenario or when a new operation is envisaged between a bunkering facility and a gas-fuelled vessel which have never conducted operations together before.

It should be revisited before each bunkering operation, starting from the moment that a bunkering operation is scheduled and before the gas-fuelled vessel reaches the bunkering location.



Who:
This stage is led by the owners and operators of the gas-fuelled vessel and bunkering facility, who should work in close collaboration with each other and with regulators and/or administrations with jurisdiction for bunkering operations in the specific location or area.

Up to this stage, the LNG supplier and receiver may have worked independently of each other or may not have had much interaction or detailed discussion. So this may be the first opportunity for all parties to discuss and agree the terms of the bunkering operation.

Goals:
During the preparation stage, the primary objective is to review and validate the work done during the design and planning stages given local (metocean/weather/port) conditions to ensure that operational roles are defined, future bunkering operations are understood and agreed by all parties and conform to the licence conditions.

1. **Defining operational roles**
   a. define the roles and responsibilities of the personnel involved in operations
2. **Understanding the operation**
   a. build a common understanding of the operation and procedures
   b. ensure all parties and equipment are ready for operations

At the end of this stage, a "go/no go" to the bunkering operation should be agreed.

Note:
The preparation stage described in this chapter aligns with Part A of the IAPH checklist (see Section 3.6).

6.2 Key Roles and Responsibilities (Preparation)

Table 6.1 below summarises the key roles and responsibilities for stakeholders who may be involved in the **Preparation Stage** of an LNG bunkering operation (see Section 3.2):

Table 6.1: Preparation stage – stakeholders' key roles and responsibilities

Preparation stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
LNG receiver (the gas-fuelled vessel owner and/or operator)	• Defines the operational roles. • Reviews and validates parameters, boundaries and conditions for the operation to go ahead • Completes the detailed compatibility assessment for agreement and inclusion in the LNGBMP.	In collaboration and agreement with other key stakeholders.
LNG supplier (the bunkering facility owner and/or operator)	• Defines the operational roles. • Reviews and validates parameters, boundaries and conditions for the operation to go ahead • Completes the detailed compatibility assessment for agreement and inclusion in the LNGBMP.	In collaboration and agreement with other key stakeholders.
Designer(s) (including facility, vessel(s) equipment designers, as applicable)	• May be consulted.	Unlikely to have an active role at this stage.
Regulator [1] (typically a national body with jurisdiction over the bunkering location; this can sometimes be the port authority)	• Overviews and, when required, validates the preparation work of the LNG supplier and receiver, based on the bunkering location/ area • Regulator may wish to observe (audit) the bunkering	In collaboration and agreement with other key stakeholders.
Port authority [1] [2]	• Overviews and, when required, validates the preparation work of the LNG supplier and receiver. based on the bunkering location/ area	In collaboration and agreement with other key stakeholders.
Terminal operator [2]	• Overviews and, when required, validates the preparation work of the LNG supplier and receiver, based on the bunkering location and any SIMOPs requirements.	Depending on the intended location (when known), which may involve installations or activities onshore.

Preparation stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
Emergency services [2]	• May be consulted during the review of the emergency planning for the operation.	Unlikely to have an active role at this stage.
Port users [2]	• May be informed.	Depending on the intended location (when known), which may involve installations or activities onshore or restrictions on passing vessels.
Neighbouring facilities and the public [2]	• May be informed.	Depending on the intended location (when known), which may impact installations or activities onshore and/or in public areas.

Notes:
[1] The regulator and port authority may in some cases have interchangeable roles.
[2] This stakeholder may be involved when the bunkering activity falls within the boundaries of a port or area of jurisdiction/interest.

6.3 Key Activities and Considerations

Special considerations are needed during the LNG bunkering preparation stage. These are discussed in the following sections, which provide specific recommendations and considerations by bunkering supply scenario and are based on industry experience and good practice.

LNG bunkering key considerations at preparation stage:

- definition of operational roles and responsibilities
- validation of bunkering requirements for:
  - bunkering scenario
  - specific location
- validation of process transfer conditions
  - maximum transfer rate
  - boil-off gas management
  - vapour return
- bunkering equipment readiness
  - connectors and connections

  - spool pieces
  - lifting gear and hose support
  - electrical isolation
  - mooring equipment
- emergency response plan review
- detailed compatibility assessment

Note:
LNG bunkering stakeholders should recognise that the key considerations above:

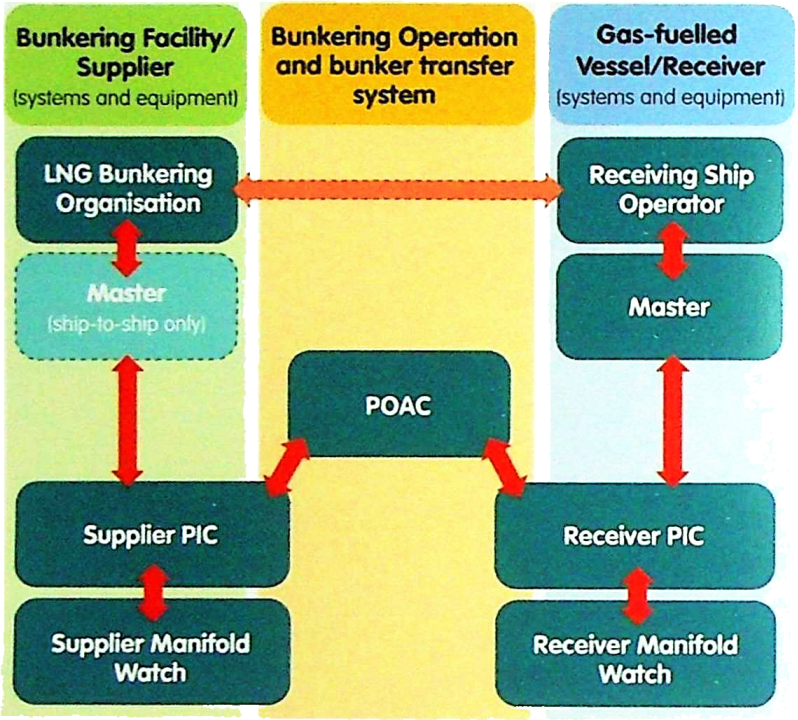
a. do not have an obvious hierarchy as to which is more important, with some assets, configurations and scenarios more sensitive or impacted than others
b. are strongly linked to each other and must be reviewed as part of an iterative process
c. are typical and general, and are not an exhaustive list. Specific designs, installations, locations and operations may require considerations beyond those discussed in this chapter

6.4 Definition of Operational Roles and Responsibilities

One of the main activities at the preparation stage is to identify and define bunkering operational roles and the responsibilities of those involved. These should be defined and agreed in advance.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator

Figure 6.1: Typical operational roles, remits and communications map



Considerations and recommendations

1. The key stakeholders – the owners and operators of the bunkering facility and the gas-fuelled vessel – should define, assign and agree the operational roles at this stage:
   a. the main difference from the "LNG bunkering key stakeholders" defined in Section 3.2 is that the operational roles encompass the personnel that will play an active role during the bunkering operation, and therefore have direct overview and responsibility over the next "operational stage" of bunkering
   b. competence and training requirements are a key factor in assigning roles
2. Six main roles are considered in these guidelines, as defined in Section 3.2.2:

a. roles may be performed by an individual or by a group, depending on the extent of the role's responsibilities and tasks
b. the number of individuals assigned to an operational role should be proportionate to the type of bunkering, its complexity and its duration
c. a handover procedure should be in place for bunkering operations that take a long time, perhaps across more than one shift

3. This is not intended to be a rigid division of responsibilities between the various organisations and individuals involved in the planning and execution of a bunkering operation. Rather, it should be considered a starting point that may be modified and accepted by the applicable parties during the pre-bunkering phase of the operational stage (see Chapter 7).

As an aid to the bunkering stakeholders, and to facilitate the definition of operational roles, Figure 6.1 lists typical responsibilities, as well as their remits and main communication and reporting lines. These may be tailored to a specific bunkering supply scenario and location.

6.4.1 LNG bunkering organisation – typical responsibilities

LNG bunkering organisation – typical responsibilities	
Appointed by who and when	Appointed by the bunkering facility's owner and operator during the preparation stage, may be the same as during the planning stage.
Communicate with	Communicate with the supplier PIC or the master for ship-to-ship operations. Liaise with the receiving ship operator.
Key responsibilities	• planning the specific operation • informing the port authority in advance for the necessary preparation of the bunkering operation and receiving any necessary permissions • operation of the facility in line with plans and procedures • maintenance of the bunkering equipment • provision of sufficient competent staff to operate their facility

6.4.2 Receiving ship operator (RSO) – typical responsibilities

Receiving ship operator (RSO) – typical responsibilities	
Appointed by who and when	Appointed by the gas-fuelled vessel's owner and operator during the preparation stage; may be the same as during the planning stage.
Communicate with	Communicate with the master. Liaise with the LNG bunkering organisation.
Key responsibilities	• planning for safe SIMOPs during LNG bunkering • preparation of the receiving vessel bunkering installation, including all safety equipment • ensuring all personnel have completed the required training • maintenance of the bunkering equipment • provision of sufficient competent staff to operate the facility • if truck to ship bunkering is to take place, discuss the operation with the location and agree necessary safety precautions and how these will be implemented

6.4.3 Master – typical responsibilities

Master – typical responsibilities	
Appointed by who and when	Appointed by the gas-fuelled vessel's owner and operator during the preparation stage. *Note* In ship-to-ship operations, a second master for the LBV is appointed by the bunkering facility's owner and operator. Receiver and supplier masters have similar responsibilities, applicable to their own vessels
Communicate with	Gas-fuelled vessel's master: communicate with the receiving ship's operator and the receiver's PIC. LBV's master: communicate with the LNG bunkering organisation and the supplier's PIC.

Master – typical responsibilities	
Key responsibilities	The master retains overall responsibility for the safe operation of the ship throughout the bunkering operation. If the bunkering operation deviates from the planned and agreed process, the master retains the right to terminate the process. The master has overall responsibility for the following aspects of the bunkering operation – these tasks may be delegated to the PIC, other responsible crew member or shore-based personnel, but overall responsibility is retained by the master • approve the quantity of LNG to be bunkered • approve the composition, temperature and delivery pressure of LNG to be bunkered • ensure that the approved safe bunkering process is followed, including compliance with any environmental protection measures required by international, national or local port regulations • agree the transfer procedure – including vapour return requirements, cooling down and, if necessary, gassing-up – the maximum transfer rate at all stages, and the volume to be transferred • ensure that company-specific operating procedures are followed, and that the operation is conducted in compliance with all applicable local and/or national regulatory requirements • make and monitor all required communications with the appropriate authorities • agree the mooring arrangement and, where applicable, the nominated mooring master during the operation • complete and sign the bunkering checklist • ensure a procedure is in place and, in the event of an emergency, manage the emergency procedures • monitor the climatic conditions throughout the operation • monitor the mooring arrangement's integrity • supervise the unmooring and separation of the ships or, in the case of truck bunkering, arrival and departure of the truck as applicable • provide sufficient trained and competent personnel • ensure that the location is aware of the bunkering operation and has taken the appropriate precautions, e.g. laying out the safety zone, informing staff

6.4.4 Person-in-Charge (PIC) – typical responsibilities

Person-in-charge (PIC) – typical responsibilities	
Appointed by who and when	There are two PIC positions: one is appointed by the owner and operator of the gas-fuelled vessel; and the second by the owner and operator of the bunkering facility. Both are appointed during the preparation stage.
Communicate with	Communicate with the receiving ship's operator or the LNG bunkering organisation and the master, as appropriate. Liaise with the POAC and coordinate the manifold watch.
Key responsibilities	The PIC should be suitably qualified, trained to fulfil the role, and have an adequate level of authority. The PIC should not be assigned any additional duties during the bunkering operation that may distract them from focusing on bunkering responsibilities. The PIC should ensure that: • relevant approved procedures are properly applied • safety standards are complied with, in particular within the hazardous zone and safety zone • the emergency response plan is initiated, if/when required To achieve this, the PIC should be responsible for: • ensuring that all required reports are made to the appropriate authorities • conducting a pre-operation safety meeting with the responsible officers of both the bunkering facility and the receiving ship (other attendees are optional) • ensuring that all bunkering documentation is completed (checklists, bunker delivery note and so on) • ensuring all safeguards and risk mitigation measures are in place • monitoring the fuel transfer and discharge rates, including vapour management • monitoring any other communications throughout the operation • supervising the connection and disconnection of liquid and vapour hoses/pipes including purging, leak testing and draining • supervising the deployment/return of fenders and/or additional support to the bunker ship • advising the master when bunkering starts and is completed • ensuring that, when necessary, any incident is reported and the report submitted to relevant parties

6.4.5 Person-in-Overall-Advisory-Control (POAC) – typical responsibilities

Person-in-Overall-Advisory-Control (POAC) – typical responsibilities	
Appointed by who and when	This role is typically assumed during the bunkering operation (when the supplier and receiver are alongside) by either the supplier's or receiver's PIC. In some cases, the POAC may be someone other than the PICs. Appointed during the preparation stage and no later than the start of the pre-bunkering phase of the operational stage. Refer to. Lessons Learned 6-1: When is a POAC required?
Communicate with	Liaise with the counterpart LNG bunkering PIC.
Key responsibilities	It is recommended that the technical aspects of the bunkering operation should be under the coordination of one individual and that the receiving vessel and the supply facility designate a POAC. The POAC should ensure that there is coordination between the operations conducted by the supplier and receiver. To achieve this, in addition to the responsibilities of a PIC, the POAC should be responsible for: • ensuring safe procedures are followed and the successful connection of liquid and vapour transfer hoses and associated safety systems • ensuring that safe procedures are followed and that purging and leak testing of the bunkering system are successfully completed, prior to transfer • initiating the fuel flow, ramp-up/down, and stopping the bunkering • ensuring that the operation remains within the accepted environmental window for the duration of bunkering • ensuring that safe procedures are followed for drainage and purging of the bunkering system, prior to disconnection

6.4.6 Manifold watch – typical responsibilities

Manifold watch – typical responsibilities	
Appointed by who and when	There are two manifold watch positions: one appointed by the supplier's PIC; and the second by the receiver's PIC. Both positions should be agreed during the preparation stage and appointed during the operational stage.
Communicate with	Communicate with their respective PICs.
Key responsibilities	The manifold watch should: • be able to communicate with the PIC during the entire bunkering operation • monitor the manifold, hose(s)/hard arm, hose support(s) and connector(s) – either on the deck or via CCTV • ensure that nothing abnormal occurs during bunkering • be vigilant and report any potential hazards to the operation – for example, the approach of a fast-moving vessel/vehicle, or a vessel/vehicle that appears to be on a collision course.

Lessons Learned 6-1: *When is a POAC Required?*

As discussed in Section 6.4, to perform the bunkering operation safely a number of individuals/organisations are required, and these are typically nominated and appointed during the preparation stage.

Among these, key operational roles are the person-in-charge (PIC) and the person-in-overall-advisory-control (POAC) – but there is often confusion as to when these roles are required and how they should interact.

The following aims to clarify the requirements for the appointment of PICs and the POAC:

1. Two PICs for the bunkering operation should always be appointed, no matter how big, small or complex the bunkering operation may be. One is nominated by the receiver, the second by the supplier.
2. The POAC role may be appointed in some circumstances in addition to the two PICs, but this role may not always be needed. Note that:
   a. the role can be fulfilled either by the supplier's or receiver's PIC or, in some cases, a different person

b. the POAC has an overarching management role with the objective of coordinating and supporting the activities among all the parties, including the PICs

3. The option of appointing a POAC in addition to the two PICs may be considered when the bunkering operation is:
   a. considered complex, perhaps due to a large number of parties involved, multiple SIMOPs, or taking place in a busy or congested location
   b. performed for the first time and/or one of the parties involved is new or unfamiliar with the bunkering operation
   c. unconventional – for example, when there is the need to deviate from normal bunkering procedures due to operational constraints or requirements. These need to be within the bunkering licence approval
4. The need to appoint a POAC may be waived when the bunkering operation:
   a. does not deviate from well-established and tested procedures
   b. the two PICs have clear communication and understanding of each other's tasks and activities, and mutually check with each other
5. Ultimately, whether or not to appoint a POAC is a choice that needs to be agreed between the LNG bunkering organisation and the receiving ship's operator.

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6.5 Validation of Bunkering Requirements

Bunkering operational requirements should be reviewed and validated at this stage, based on:

- the bunkering scenario, including the precise systems and configurations of the gas-fuelled vessel and the bunkering facility, and their equipment
- the bunkering location, considering the specific boundary conditions and activities in the designated bunkering location

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator

Considerations and recommendations

1. The owners and operators of the bunkering facility and the gas-fuelled vessel should ensure:
   a. that local authorities and stakeholders are informed and/or engaged, as applicable
   b. that any generic risk and SIMOPs assessments or previous studies completed to date are applicable and usable
2. The owners and operators of the bunkering facility and the gas-fuelled vessel should review and validate, at the agreed time of bunkering:
   a. that recommendations and mitigations identified during the planning stage bunkering operational risk assessment have been implemented (see Section 5.6.1)
   b. that safety zone studies are still valid, taking into consideration any location-specific hazards or constraints (see Section 5.6.2)
   c. that recommendations and mitigations identified during SIMOPs studies are still valid, taking into consideration any location-specific operations that might impact the bunkering (see Section 5.7)
3. Wherever notable discrepancies or shortfalls are found, the owners and operators of the bunkering facility and the gas-fuelled vessel should review and update:
   a. the operational risk assessment

b. the safety zone study
c. the SIMOPs assessment
d. bunker transfer conditions

6.6 Validation of Process Transfer Conditions

At this stage, the key LNG process transfer conditions and boundaries should be validated and agreed by all the parties.

This step addresses the general procedures for the bunkering process, considering elements such as flow rate and boil-off gas (BOG) management, based on the anticipated typical condition of the LNG as fuel, including the temperatures and pressures of the supply and receiving tanks.

Process transfer conditions and procedures should be checked by the supplier's and receiver's PICs before each bunkering to validate whether they are still within the expected boundaries or whether corrective/alternative actions may be required.

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator

6.6.1 Maximum transfer rate

Considerations and recommendations

1. The maximum allowable LNG transfer rate to be used for bunkering needs to be determined taking the following into consideration:
   a. the maximum allowable flow rate of the bunker station manifold/ transfer system, whichever is the smaller
   b. the maximum allowable cooling-down rate, taking into account induced thermal stresses in the transfer system, the LNG receiving ship's piping and tank
   c. the ability to control and manage flash gas generated during bunkering
   d. the expected temperature of the LNG to be supplied from the bunkering facility
   e. the expected temperature of the LNG remaining in the receiving ship tank

f. the expected pressures in the bunkering facility tank and the receiving ship tank and how they will change over time
g. the time-point of the bunkering process (that is, topping-up, bulk transfer, ramp-up/down)
h. the available time window for bunkering

2. The LNG velocity in the bunkering line piping system, hose and so on should not exceed 12 m/s to avoid the generation of static electricity, additional heat and excessive generation of BOG due to non-linear flow (see Lessons Learned 3-1: Bunkering Supply Scenario Versus Volume and Flow Rate, on page 19).
3. The maximum transfer rate allowed for each bunkering operation should be adjusted and agreed by the two PICs before bunkering begins, based on the actual LNG process conditions. It should never exceed the maximum transfer rates defined in points (1) and (2) above.

6.6.2 Managing boil-off gas

Adequate provisions should be made for the control and management of the flash gas generated during bunkering, without release to the atmosphere.

Considerations and recommendations

1. Bunkering transfer parameters should be tailored and adjusted during bunkering to minimise and control the production of flash gas and/or displaced gas in the receiving tank(s).
2. The most relevant factors that will affect the amount of flash gas generated during a typical bunkering operation are:
   a. cool-down of the transfer system and bunkering line (this can generate large quantities of BOG but has a short-term effect)
   b. different conditions in the bunkering facility tanks and the receiving tanks (in particular, the temperature of the receiving tank can have long-lasting effects on BOG production during the whole transfer)
   c. transfer rates (ramp-up, full flow, ramp-down/topping-up)
   d. heat gain in the pipeline and transfer equipment between the bunkering facility's tank and the receiving ship's tank
   e. pumping energy
3. During the preparation stage the maximum tank pressures should be agreed to prevent any inadvertent gas release to the atmosphere.
4. The agreed BOG management strategy and procedures need to be

defined in the operating procedures. This may be done by any of these means, individually or in combination:
   a. allowing pressure to build up in one or both systems
   b. cooling the vapour space to control/collapse the pressure by using LNG top-filling lines in the receiving tank
   c. returning gas to the bunkering facility via a vapour return line (see Section 6.6.3)
   d. liquefaction of gas with a reliquefaction plant
   e. consumption of gas in boilers, gas combustion units or gas engines
5. If the parties are unable to control the rise in LNG tank pressure, they should:
   a. stop the bunkering operation until the LNG tank pressure can be managed effectively, or
   b. terminate the bunkering operation immediately

6.6.3 Using a vapour return line

The use of a vapour return line during bunkering can facilitate BOG management between supplier and receiver and help to control and maintain the correct pressure in the receiving tank(s) (see Section 6.6.2). Furthermore, using a vapour line can provide a further benefit in reducing the time required for the whole bunkering operation, so this may be considered when bunkering has stringent time constraints.

Considerations and recommendations

1. For bunkering:
   a. without vapour return, the receiver LNG bunker tank pressure is controlled solely by the gas-fuelled vessel
   b. with vapour return, the receiver LNG bunker tank pressure can be controlled by the gas-fuelled vessel, with support from the bunkering facility, via the vapour return
2. SGMF guidelines on manifold arrangements, TGN 06-04, recommend that all gas-fuelled vessels have a liquid and vapour manifold at the bunker station. The owner and operator of the gas-fuelled vessel should have in place a procedure for the connection and use of a vapour return line.
3. Most but not all bunkering facilities (for example, road trailers) are able to connect a vapour return line to assist the gas-fuelled vessel.

Receivers should be aware of this and plan tank pressure-management accordingly.

4. If it is anticipated that the use of vapour return may be required, the operator of bunkering facility may consider connecting and having a vapour return line ready to use from the gas-fuelled vessel to the bunkering facility. It is not good practice to connect a vapour return line as an emergency measure to control BOG while bunkering is in progress.

6.7 Bunkering Equipment Readiness

Bunkering equipment should be made available, checked, tested, and prepared for use in operations during the preparation stage.

This activity addresses the following:

- Who supplies which piece of the bunker transfer system?
- Is all the right bunkering equipment available?
- Does each party understand how all the equipment should be used?

It should not be confused with the checking and testing carried out during the pre-bunkering phase of the operational stage (see Section 7.3.2).

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator

The following discussion on some of the equipment used in bunkering operation is not exhaustive. It focuses on a limited number of items that, based on current experience, require particular attention or are often overlooked.

6.7.1 Connectors and connections

The means of connecting the bunker transfer system to the receiving vessel manifolds should be discussed and agreed at this stage. Connections may be achieved by:

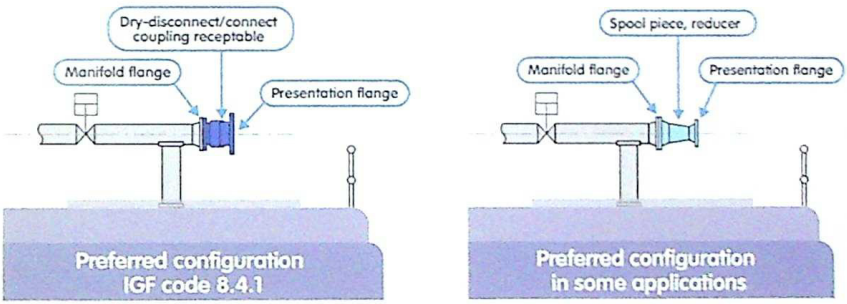
- a dry-disconnect/connect coupling (DD/CC) with a nozzle fixed on the transfer system and a receptacle bolted on the receiving manifold flange (see Figure 6.2)
- a standard flange (see Figure 6.2)

The choice of method is determined by:

- statutory requirements
- operational constraints and preferences

Once the supplier and receiver have agreed on the method, the relevant equipment should be made available.

Figure 6.2: Receiving manifold connection options and layout



Considerations and recommendations

1. A dry-disconnect/connect coupling (DD/CC) is a type of quick-connect/disconnect coupling (QC/DC):
   a. they are manually operated mechanical devices that enable quick connection and disconnection of the transfer system to the manifold of the receiving vessel, without employing bolts. Their additional key feature is an internal self-sealing valve that activates during disconnection (see Figure 6.3)

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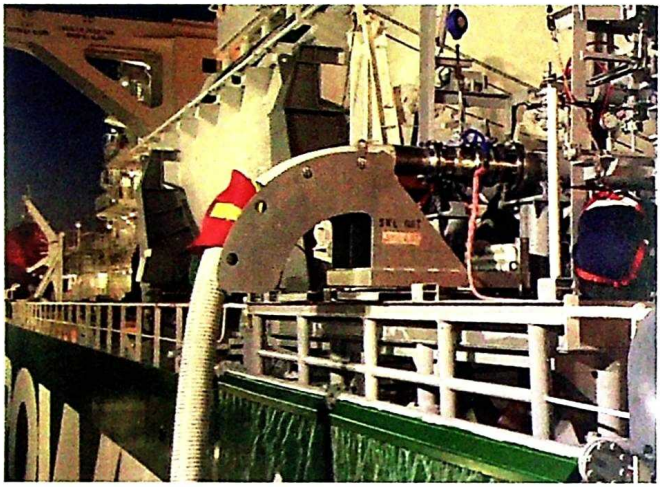
Figure 6.3: An example of a DD/CC connection in operation (Picture courtesy of Harvey Gulf International Marine)



b. the IGF Code's Section 8.4 Regulations for manifold requires the use of a "coupling of standard type" for the manifold connection. SGMF recommends the use of a DD/CC compliant with ISO 21593:2019 (Technical requirements for liquefied natural gas bunkering dry-disconnect/connect coupling).
c. when DD/CCs are employed, great care should be taken to ensure a secure and safe connection. This is achieved by:
   i. obtaining correct alignment between nozzle and receptacle
   ii. avoiding the transmission of bending forces/loads by the transfer system (hose) to the DD/CC
d. further guidance on the connection and use of DD/CC is provided in the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06:*
   i. TGN06-06 – Tips and Lessons Learned B-2: DD/CC Connection Technique
   ii. TGN06-06 – Tips and Lessons Learned B-16: Inerting when DD/CCs are used
e. when DD/CCs are used, supplier and receiver should agree:
   i. the coupler type
   ii. who is responsible for supplying the DD/CC receptacle to the receiving manifold

2. Receiving manifold flange connection option.
   a. connection to a standard manifold presentation flange is an alternative option to the use of a DD/CC connection
   b. flange connection may be permitted by the IGF Code by following the section "2.3 Alternative design"
      i. the alternative design must be approved by the administration, following the requirements of the IGF Code
      ii. SGMF regards it as good practice to use the ASME B16.5 class 150 RF flange type, to enhance standardisation of the gas-fuelled vessel's bunker manifold flange connection
   c. when flange connections are employed, additional care should be taken to ensure a dry-disconnect operation. The flange option should be combined with operating procedures that ensure disconnection is achieved without any release of gas to the atmosphere;
   d. further guidance on use of flange connections is provided in the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06*
      i. TGN06-06 – Tips and Lessons Learned B-1: Connection – Good to Know
      ii. TGN06-06 – Tips and Lessons Learned B-17: Disconnecting – Good to Know

6.7.2 Spool pieces

The bunker transfer system is often connected to the gas-fuelled vessel via a DD/CC (see Section 6.7.1), but a spool piece or reducer may also be used. Additionally, suitable strainers should be installed.

Considerations and recommendations

1. The number and sizes of spool pieces or reducers needed should be agreed between the supplier and receiver. Additional considerations should be given to:
   a. which party is responsible for providing spool pieces or reducers
   b. the suitability of the gasket bolts and torque-setting device for the connection
2. To facilitate gas-fuelled vessel bunkering at a variety of bunkering facilities, it is recommended that the gas-fuelled vessel is provided with a standard set of spool pieces and reducers, appropriate

to the number of manifold connections on board (ref: TGN06-04, Ver1.0 § 5.4.1).
3. Where spool pieces or reducers are used, they should be installed prior to bunkering and tested as part of the preparation for bunkering. Leak testing ensures that the arrangement, including the spool piece, is fully inerted and gas-tight before transfer (refer to the pre-bunkering phase of the operational stage in Section 7.3).

6.7.3 Lifting gear and hose support

To facilitate the connection of the bunker transfer system to the receiving manifold, suitable lifting gear is required by the bunkering facility as well as on board the gas-fuelled vessel (see Figure 6.4).

Considerations and recommendations

1. The need for lifting gear, and its capacity and safe working load, should be agreed between supplier and receiver. Additional consideration should be given to:
   a. which party is responsible for providing the lifting equipment
   b. the suitability of the equipment and the inspection and testing regime
2. To facilitate bunkering at a variety of bunkering facilities, it is recommended that the gas-fuelled vessel is equipped with suitable lifting gear and lifting points, appropriate to the operation, to help the supplier during connection of the bunker system (ref: TGN 06-06, Ver1.0 § 5).

Figure 6.4: An example of lifting equipment used during the connection operation (Picture courtesy of Manntek)

6.7.4 Electrical isolation

Electrical isolation should be in place on all bunkering lines to prevent galvanic current flow between the receiving vessel and the bunker facility and to manage any static generated as part of the flow of LNG through the bunker transfer system.

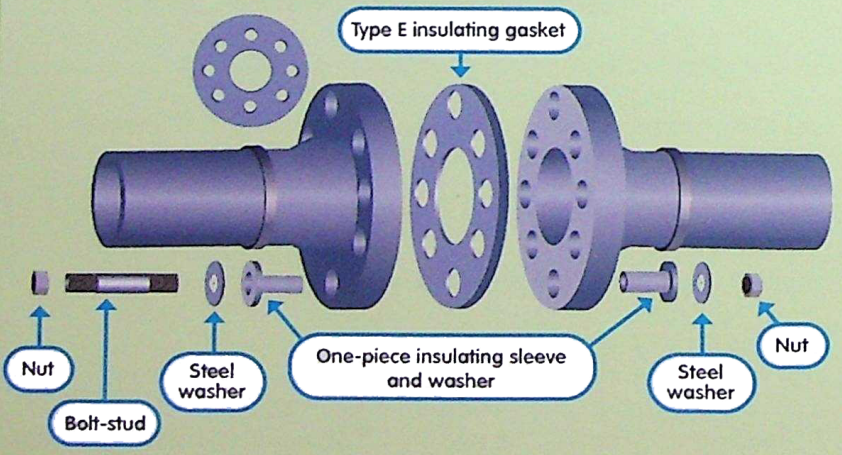
Considerations and recommendations

1. Electrical isolation may be achieved by:
   a. using a suitable insulating flange
   b. avoiding contact between conductive surfaces
2. Please refer to Lessons Learned 6-2: Electrical Isolation Considerations for good practice electrical isolation procedure during bunkering, including the use of bonding cables.

Lessons Learned 6-2: *Electrical Isolation Considerations*

1. Electrical isolation should be in place on all bunkering lines.
2. Typical and recommended means of electrical isolation include:
   a. for truck-to-ship transfers, using an insulation flange and, where required by local regulations, a bonding cable. If bonding cables are used, they should not be connected or disconnected in hazardous areas due to the risk of sparking
   b. for ship-to-ship transfers, equal electrical potential between supplier and receiving vessels should be achieved by means of an insulation flange
3. Regarding the **Insulation Flange** type and arrangement:
   a. insulating flanges have high electrical resistance so that the high voltages created by static charging are bled off across the flange joint, but low-voltage currents that flow from the batteries of each vessel are blocked from interacting with each other
   b. the insulation flange should:
      i. have a resistance of more than 1,000 ohms, to limit low-voltage current flow but should be less than 100 megohm to ensure dissipation of static charge
      ii. be installed as per the arrangement in Figure 6.5

Figure 6.5: A typical Insulation flange arrangement.



4. Regarding the location of the **Insulation Flange**:
   a. it should be fitted where it is least likely to be disturbed or shorted-out; for example in hose systems it might be fitted close to the bunkering supply manifold or in hose/arm hybrid systems it might be fitted at the join between arm and hose
   b. its position should be clearly marked
   c. care should be taken to ensure the hose is not touching the hull or other surfaces, where it could create a bond to the ground and a potential spark
   d. any lifting or supporting device should be prevented from short-circuiting any insulation flange
   e. depending on the location of the insulating flange, additional electrical insulation may be required between the hose bunker system and the gas-fuelled vessel/bunkering facility structure, as well as at the lifting points
5. Use of **Bonding Cables**:
   a. some administrations require the use of bonding cables:
      i. where this is the case, they should be attached to the ship, outside of the bunkering area, and be isolated by a switch in an intrinsically-safe enclosure
      ii. circuit continuity should be made via a "certified-safe" switch (such as one housed inside an Ex-enclosure) and the connection on board the ship should be in a location outside of any hazardous areas. The switch should not be closed until the bonding cable/strap has been connected, and it should be opened prior to disconnection of the bonding strap
   b. however, note that the bonding cable is unlikely to be effective against a static charge generated in the hose bunker system, which is the most likely source of a spark, reinforcing the need for insulating flanges. Further information on bonding and static electricity risks and management can be found in the sixth edition of the International Safety Guide for Oil Tankers and Terminals (ISGOTT)
   c. given the above, the use of bonding cables for LNG bunkering should be agreed by all the parties involved. Factors to be considered include administration requirements, the hose bunker system layout, bunkering conditions, and operator preferences expressed during the pre-bunkering meeting

6.7.5 Mooring equipment

Additional consideration should be given to the required mooring equipment, particularly for ship-to-ship operations (see Figure 6.6).

Considerations and recommendations

1. The need for, number and size of mooring lines and fenders for ship-to-ship bunkering should be agreed in advance by the supplier and receiver.
2. Additional consideration should be given to:
   a. the size of the fenders, taking into account bending radius limitations of the bunkering hoses
   b. the size of the fenders, taking into account expected roll motions of the vessels to prevent the vessels clashing
   c. the location of fenders and mooring lines, which should be well clear of the bunker system, and the supplier and receiver manifold areas
   d. the mobility of fenders for placement on the bunker vessel and the flat side of the gas-fuelled vessel, on either side of the manifolds
3. Further information for ship-to-ship operations may be found in the OCIMF publication *Ship-to-Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases.*

Figure 6.6: An LNG bunker vessel during mooring. Note the use of floating fenders and additional pneumatic fenders between hulls to prevent bunker hoses being crushed in the vent of excessive roll (Picture courtesy of Shell)

6.8 Emergency Response Plans Review

The Emergency Response Plans developed by each respective organisation during the planning stage should be reviewed to ensure they are compatible, roles and responsibilities understood and resources required under the emergency response plan have been prepared (see Section 5.9).

Key activity stakeholders (see Section 3.2)	
Who:	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator • Port authority/terminal operator (as required) *with the involvement of* • Emergency services

Considerations and recommendations

1. During the planning stage, emergency response plans may be developed independently by an organisation, or in collaboration with other parties. During the preparation stage the emergency response plans should be reviewed, based on the expected bunkering conditions, location and roles as identified in Sections 6.4, 6.5 and 6.6.
2. At this stage, the review of the emergency response plans should include, as a minimum:
   a. ensuring emergency plans are compatible with the actual operation that will be conducted (for example, emergency plans for truck-to-ship bunkering are not deemed compatible and suitable for ship-to-ship operations, so an appropriate new plan should be developed)
   b. ensuring that the resources required under the emergency response plan are available/prepared.
   c. ensuring that personnel are trained and that drills have been conducted
   d. agreeing clear evacuation procedures and communicating them to all relevant personnel
   e. ensuring that the agreed roles and responsibilities of all parties are clear and communicating them to all relevant personnel
   f. ensuring contact numbers are available for all relevant emergency services
   g. for the port/local authority, ensuring that the emergency services, such as firefighters and medics, have been made aware as applicable that LNG bunkering operations are scheduled.

6.9 Detailed Compatibility Assessment

The preliminary bunkering compatibility assessment (see Section 5.10) should be reviewed and validated at this stage through a detailed compatibility assessment, taking into consideration the actual design and configuration of the gas-fuelled vessel and bunkering facility.

Key activity stakeholders (see Section 3.2)	
Who.	• Gas-fuelled vessel: owner and operator • Bunkering facility: owner and operator

Considerations and recommendations

1. To complete the detailed compatibility assessment:
   a. the design and particulars of the gas-fuelled vessel and bunkering facility should be fully known and the design packages for both should be complete and available
   b. the supplier's and receiver's bunkering procedures should be agreed and available
   c. safety zones and SIMOPs assessments should be complete and available
   d. the emergency response plan should be agreed and available
2. The overall objective of the detailed compatibility assessment is to assess and validate the unique and specific aspects of each step of the operation, for each interface.
3. The detailed compatibility assessment may be undertaken with the assistance of a suitable checklist, and the outcome and recommendations should be recorded, and a report included in the LNGBMP
4. The owners and operators of gas-fuelled vessels and bunkering facilities should develop their own procedures to validate compatibility between supplier and receiver:
   a. these may vary, depending on the type of bunkering supply scenario, systems configurations and layout
   b. this publication offers a high-level methodology in Lessons Learned 6-3: A Methodology for Preliminary and Detailed Compatibility Assessment, which may be tailored to support supplier and receiver in this exercise

Lessons Learned 6-3: *A Methodology for Preliminary and Detailed Compatibility Assessment*

The following methodology for the preliminary compatibility assessment and the detailed compatibility assessment may be used as a framework by the owners and operators of gas-fuelled vessels and bunkering facilities.

General considerations and background:
Bunkering compatibility can be divided into two main areas: physical and operational.

Physical compatibility refers to the requirements for the bunkering equipment and systems interfaces. This should:

1. Consider the general overall arrangement and layout of the bunkering facility and the gas-fuelled vessel, and how the two can be brought together so that the supplier and receiver manifolds are within reach of the connections.
2. Consider all the equipment used during the bunkering operation, including availability, size, type, layout and connections.
3. Consider the means of communication, including communication between PICs and data communication between safety and ESD systems.

The primary objective is to check that physical interfaces which cannot be easily changed without design modifications are compatible with each other.

Operational compatibility refers to requirements for how the equipment is operated and used within respective design specifications and limits. This should:

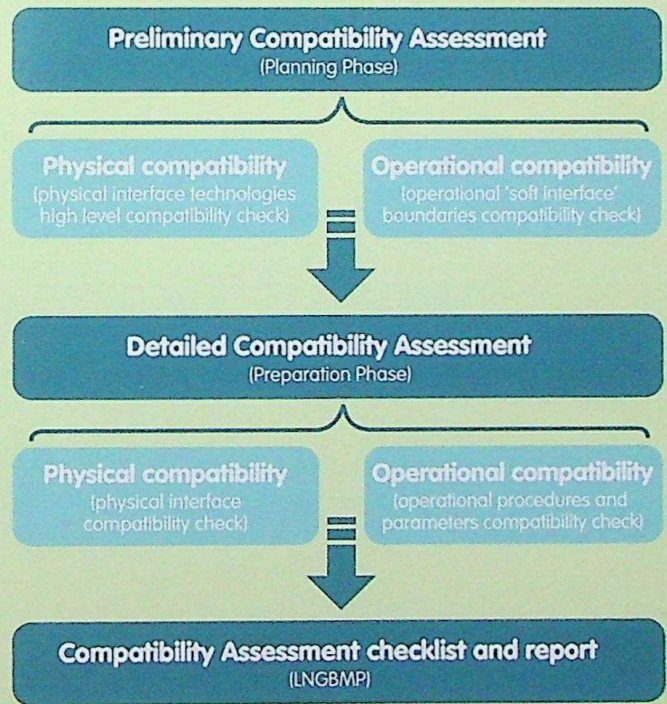
1. Consider the operational limits, settings and parameters for the bunkering equipment and systems.
2. Consider how equipment and systems are to be operated by the personnel and crew.
3. Consider the compatibility of the whole bunkering operation, with respect to other operations and the overall surroundings.

The objective is to check the "soft interfaces" that can vary from one operation to another and how they may be adjusted to be compatible in different scenarios and configurations.

Both physical and operational compatibilities are checked during the preliminary and detailed assessment – but the level of detail increases along the process.

For example, during the preliminary assessment, the physical compatibility of the ESD system is checked to determine whether both supplier and receiver have installed compatible technologies on board. If they are compatible, then, in the following detailed assessment, the emergency shutdown triggers and actions are checked for compatibility.

If they are not compatible at the preliminary stage, the issue is flagged and this may require modifications to the ESD systems or the installation of new ESD systems before proceeding any further.



Preliminary compatibility considerations

The preliminary compatibility assessment review should include the following. (Note that the involved parties should agree which aspects are relevant/applicable to their specific operational and bunkering supply scenario.)

Physical Compatibility	
Areas to check	**Supporting documentation (see Section 3.6)**
• Mooring arrangements • Bunker system envelope • Manifold arrangement and location • BSL systems • ERS	• Architecture particulars and equipment certificates package • Mooring plan • Vessel general arrangement drawings

Operational Compatibility	
Areas to check	**Supporting documentation (see Section 3.6)**
• Maximum allowable bunkering process parameters • BOG/vapour management • SIMOPs	• Architecture particulars and equipment certificates package • Bunkering step-by-step procedure and safety instructions • Safety zone and SIMOPs assessments

Items to be considered in the preliminary compatibility assessment include:

a. general mooring arrangements, flat side, location, position, fendering and so on
b. crane, boom, loading arm reach and lifting arrangements
c. manifold and bunker station location general arrangement, spacing, distancing, orientation, size and so on
d. BSL technologies available for primary and back-up systems
e. ERS technology type and location
f. bunkering process equipment such as PRV settings, instrumentation, piping, pumps for maximum allowable pressure, flow rate, cool-down rate and so on
g. BOG and vapour management philosophy (vapour return 'or' no vapour return)
h. safety zone and SIMOPs potential overlap and limitation requirements

Detailed compatibility considerations

The detailed compatibility assessment review should include the following. (Note that the involved parties should agree which aspects are relevant/ applicable to their specific operational and bunkering supply scenario.)

Physical Compatibility	
Areas to check (reconfirm or review in greater detail)	**Supporting documentation** (see Section 3.6)
• Mooring and fender placement • Bunker system deployment envelope • Manifold connector and connections • BSL connector and connections • ERS systems functionality • Hose support equipment • Operational weather and environmental conditions	• Architecture particulars and equipment certificates package • Final vessel general arrangements • As-built manifold arrangement drawings and P&IDs • Mooring assessment

Operational Compatibility	
Areas to check	**Supporting documentation** (see Section 3.6)
• Bunkering procedure • Operational roles • Process parameters, settings, and status of tanks • BOG/vapour management plan • SIMOPs • Safety zone management • ESD-1 and ESD-2 response actions • Post-bunkering purging plan	• Architecture particulars and equipment certificates package • Bunkering procedures • BOG/vapour management procedures • Safety zone calculations • Risk assessment, including SIMOPs • Emergency response plan

Items to be considered during the detailed compatibility assessment, taking into consideration the actual conditions on the day of bunkering, include:

a. detailed mooring arrangements and procedures, location, position, fendering and so on
b. draft and tidal changes
c. physical location for bunkering/environmental limitations during operations and for manoeuvring/approach
d. access points such as ramps and gangways
e. bunker system and equipment, straps, hose bun, saddles
f. manifold connectors and connection

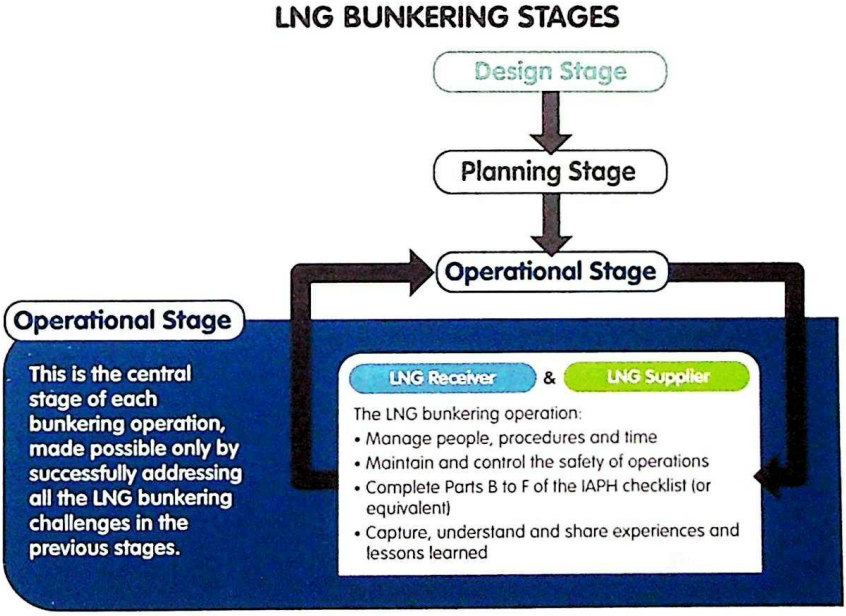
g. cryogenic protection
h. emergency response/departure
i. operational roles
j. BSL connectors and connections
k. communication plan, channels and systems
l. ESD-1 and ESD-2 actions, triggers, and cause and effect
m. detailed process parameter flow rate, cool-down rate and so on
n. nitrogen supply
o. custody transfer and measurement system
p. safety zone monitoring and securing
q. hazardous and safety zones overlap
r. SIMOPs
s. electrical isolation

7. Operational Stage - LNG Bunkering

7.1 General

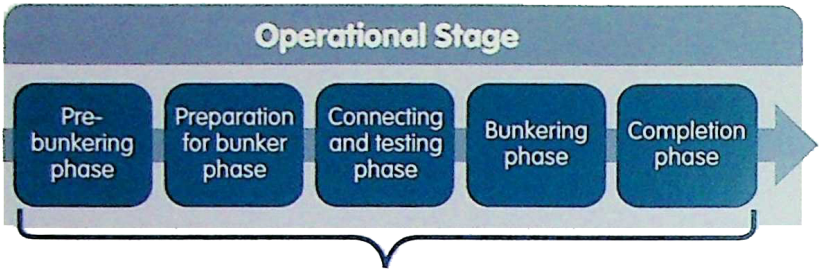
This stage focuses on the operational activities when carrying out LNG bunkering.

When
The **Operational Stage** spans from the day(s) or hours before the bunkering operation is scheduled, through to its completion and the departure of the gas-fuelled vessel and/or bunkering facility.



The operational stage can be further divided into five sequential main phases:

Figure 7.1 Operational Stage - Main Phases



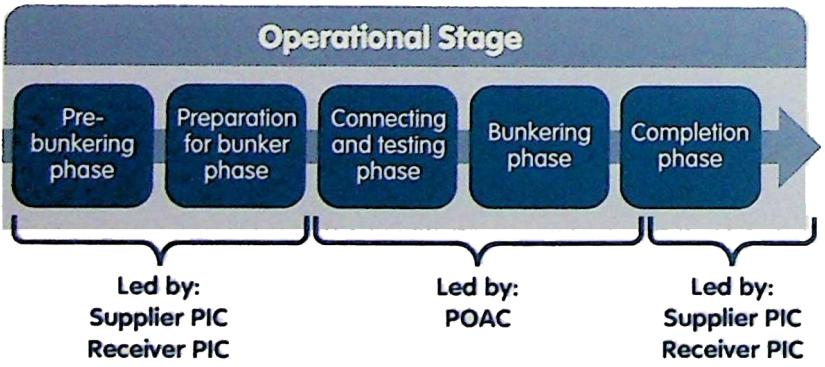
Each of the five main phases of the operational stage is described in the following chapters. The main operational and safety goals of each phase and the steps within it are discussed and a set of considerations and recommendations is provided.

Who

During this stage, the LNG bunkering organisation and receiving ship operator work in close collaboration, with the different stages led respectively by the two PICs or the POAC.

Figure 7.2 shows the typical separation of operational leading responsibilities between the PICs and the POAC (refer to: Lessons Learned 6-1: When is a POAC Required?).

Figure 7.2: Typical responsibilities of the PICs and the POAC during bunkering operations



Goals

The main objective of the operational stage is to manage people, equipment and time in an efficient manner to ensure responsible and safe operations – and that any lessons learned are captured and shared.

1. **Manage people, procedures and time**
   To ensure efficient and smooth operations.
2. **Maintain and control the safety of operations**
   To conduct operations safely and responsibly.
3. **Continuous learning**
   To capture, understand and share experiences and lessons learned.

7.2 Key Roles and Responsibilities (Operation)

Table 7.1 below summarises the key roles and responsibilities of stakeholders (see Section 3.2) who may be involved in the operational stage of an LNG bunkering operation, while roles and responsibilities for the operational stage, as defined in Section 3.2.2, are presented in Table 7.2.

Table 7.1: Operational stage – stakeholders' key roles and responsibilities

Operational stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
LNG receiver (the gas-fuelled vessel owner and/or operator)	• See Table 7.2	Active role taken by the **receiving ship operator.**
LNG supplier (the bunkering facility owner and/or operator)	• See Table 7.2	Active role taken by the **LNG bunkering organisation.**
Designer(s) (including facility, vessel(s) equipment designers, as applicable)	• May be consulted.	It is unlikely they will have an active role at this stage.

Operational stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
Regulator [1] (typically a national body with jurisdiction over the bunkering location; this can sometimes be the port authority)	• Authorises [3], oversees the operation, as applicable.	In collaboration and agreement with other key stakeholders.
Port authority [1] [2]	• Authorises [3], oversees the operation, as applicable.	In collaboration and agreement with other key stakeholders.
Terminal operator [2]	• Authorises [3], oversees the operation, as applicable	Depending on the intended bunkering location.
Emergency services [2]	• Oversee the operation, as applicable. • Provide support, as requested.	In collaboration and agreement with other key stakeholders.
Port users [2]	• May be informed.	It is unlikely they will have an active role at this stage.
Neighbouring facilities and the public [2]	• May be informed.	It is unlikely they will have an active role at this stage.

Notes:
[1] In some cases, regulators and port authorities may have interchangeable roles.
[2] This stakeholder may be involved when the bunkering activity falls within the boundaries of a port or area of jurisdiction/interest.
[3] The authorisation process for the bunkering operation varies by area and/or location.

Table 7.2: Operational roles and responsibilities

Preparation stage – stakeholders' key roles and responsibilities		
Stakeholder	**Key roles and responsibilities**	**Remarks**
LNG bunkering organisation	• Applying a specific LNG bunkering procedure for the specific ship and bunkering facility, based on pre-selected LNG bunkering guidelines. • Liaises with the operations partners, ensuring that information is exchanged, LNGBMP documentation is maintained, and applicable approvals are obtained	In collaboration and agreement with other key stakeholders.
Receiving ship operator	• Develops a specific LNG bunkering procedure for the specific ship and bunkering facility, based on pre-selected LNG bunkering guidelines. • Liaises with the operations partners, ensuring that information is exchanged, LNGBMP documentation is maintained, and applicable approvals are obtained	In collaboration and agreement with other key stakeholders.
Master(s)	• Responsible for the overall safety of the vessel and its operations.	Typically delegates actual bunkering activities direction to the PIC.
Person-in-Charge (PIC) [1]	• Directs and overviews the preparation and the operation of the bunkering facility or the gas-fuelled vessel.	In collaboration and agreement with the PIC counterpart.
Person-in-overall-advisory-control (POAC) [2]	• Directs and overviews the bunkering operations from the moment of connection to the moment of disconnection of the bunker system.	In collaboration and agreement with the PIC counterparts.
Manifold watch/ hose watch	• Provides support at the manifolds and bunker system areas	Under direct control of the PIC.

Notes:
[1] The roles of PICs start during the preparation stage and continue through operation and completion until the supplier and/or receiver have departed.
[2] The POAC role is one of coordination and is typically performed by one of the two PICs. It is in force only while the supplier and receiver are alongside.

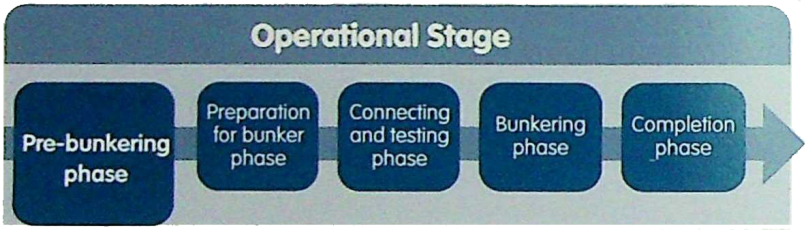
7.3 Pre-Bunkering Phase

Note:
The pre-bunkering phase described in this section aligns with Part B of the IAPH checklist (see Section 3.6) and starts from the day(s) or hours leading up to the operation.

Goal

The pre-bunkering phase ensures that all assessments and authorisations have been completed and/or obtained and that procedures are agreed between the supplier and receiver PICs before operations begin.

Key activities/steps



Key activities/steps:

1. Check that the LNGBMP has been established and is applicable.
2. Ensure that the initial preparation/operational readiness checks are conducted and passed.
3. Check that the necessary authorities have been informed about the LNG bunkering operation and that they have given their approval (if required).

Considerations and recommendations

1. Pre-bunkering phase activities should be completed as applicable by both supplier and receiver, under the supervision/direction of their respective PICs, who from this moment should start to liaise directly with each other.
2. It is recommended that activities within this phase are undertaken well before the operation. Whenever possible, this should be 48-72 hours in advance, particularly for new operations, complex bunkering scenarios

or when multiple stakeholders are involved.
3. If the pre-bunkering phase occurs too close in time to the next phase, there may not be enough time to rectify any issues that may be identified. If major safety issues are found and not addressed, it may not be possible to proceed with bunkering, or it may be delayed or prolonged.

7.3.1 LNGBMP and JBP applicable and established

Refer to Section 3.6.

PICs should ensure that an LNG Bunkering Management Plan has been established and is applicable to the ship and to the intended operation, where required a Join Bunkering Plan should be also been established. This includes the following:

1. All documents that comprise the LNGBMP should be complete and available.
2. The compatibility assessment should be complete and any recommendations and requirements addressed.
3. Clear bunkering procedures for the specific operation should be available (e.g. in the JBP) and understood by the relevant parties.
4. The quantity and quality agreement should be signed off by the supplier and receiver organisations.

7.3.2 Check readiness to operate

Refer to Section 6.7.

1. The risk assessment should be complete and current, and its findings implemented.
2. The SIMOPs operations to be undertaken (if any) should have been defined and must be confirmed to be possible alongside the LNG bunkering operation on this occasion.
3. Boundary conditions such as transfer rate, boil-off gas handling and loading limit should have been agreed between the supplier and the ship to be bunkered.
4. All bunkering equipment should be:
   a. available
   b. properly maintained
   c. functional and ready for use

5. Ensure that bunkering facility and gas-fuelled vessel safety systems are:
   a. functional and ready for use
   b. properly maintained
   c. regularly tested
6. Ensure that the leakage detection systems (fixed and portable) are:
   a. certified
   b. properly maintained and tested (testing of such systems should be performed during this phase, if appropriate)
   c. in good condition and suitable for the service intended
7. During this phase, the LNG bunkering organisation and the receiving ship operator should consider:
   a. installing any required spool pieces or connectors to the manifold flange (see Section 6.7.2)
   b. checking for debris in manifold strainers (Ref: TGN06-04, Ver 1.0 § 6.4).

7.3.3 Authorisation and notification

Refer to Section 5.5.

1. The necessary authorities should have been informed about the LNG bunkering operation and have given their approval (if required).
   Note: Approval may be conditional based on performing certain tests/ procedures or within certain time periods.
2. Any permits or authorisations required by port or regulatory authorities should have been obtained, complied with and made available before bunkering begins.
3. Any other applicable authorities – such as local authorities, emergency services and terminals – should be notified before a bunkering operation begins. The IAPH checklist may be used to inform terminal operators of the planned operation.

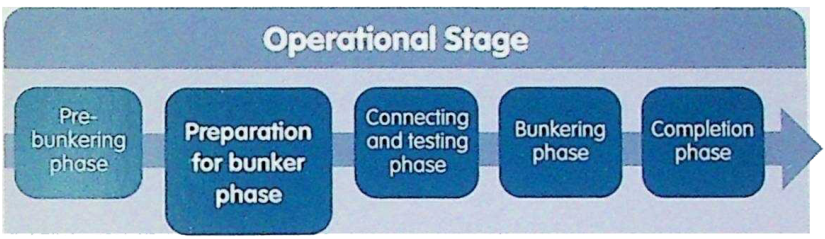
7.4 Preparation for Bunker Phase

Note:
The preparation for the bunker phase described in this section aligns with Part C of the IAPH checklist (see Section 3.6) and starts a few hours before the actual bunkering. It continues through the vessel mooring, up to the point that the parties are ready to deploy and connect the bunker system to the receiving manifold.

Goal

The preparation phase ensures that procedures are in place and equipment is ready before LNG transfer commences and that the bunkering facility and gas-fuelled vessel are ready for the next step of the operation.

Key activities/steps



Key activities/steps:

1. Bunkering equipment and safety systems preparation and confirmation of status: "Operational and Ready to use".
2. Operational steps have been taken confirming that "Bunkering can go ahead".
3. Bunkering agreement and checklist are signed off by the supplier and receiver PICs, confirming that all parties are ready to proceed.

Considerations and recommendations

1. Preparation for bunker phase activities should be completed as applicable by both supplier and receiver under the supervision/direction of their respective PICs. At the completion of this phase the designated PIC will assume the POAC role, taking the lead in directing the operation.
2. Taking actual operational requirements into account, the LNG bunkering organisation and the receiving ship operator should:
   a. tailor steps and activities recommended to be undertaken and completed in this phase
   b. include specific preparation activities, depending on equipment, bunkering supply scenario and location
   c. agree their order and when each will be undertaken

7.4.1 Preparation of bunkering equipment and safety systems

During this phase, bunkering equipment and safety systems used by the bunkering facility and the gas-fuelled vessel are prepared. This can include their inspection, deployment, installation, functional checking and testing to confirm their status as "Operational and Ready to Use".

While equipment and safety systems to be used may vary from operation to operation, the following bunkering considerations are key:

7.4.1.1 Personnel Protective Equipment (PPE)

1. All personnel involved in the LNG bunkering operation should use suitable and adequate Personal Protective Equipment (PPE) while on duty.
2. All PPE should have been checked for compliance and be "Operational and Ready to Use".
3. As a minimum, it is expected that personnel will wear:
   a. high, antistatic safety boots with watertight flaps
   b. high visibility, antistatic protective clothing, which must completely cover the arms and legs
   c. a helmet with face shield
   d. gloves suitable for low temperatures (such as Cryo-gloves)
   e. personal gas meters (such as flammable, oxygen and gas meters)
   f. a harness and lanyard (where required)
   (ref: ISO20519:2019 § 6.5.10)

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Figure 7.3: LNG bunkering crew PPE

7.4.1.2 Communication system(s)

1. A communication system with a back-up should be provided between the bunkering facility and the gas-fuelled vessel:
   a. there should be at least two suitable and independent means of communication available at all times during bunkering
   b. no transfer operations are to begin until effective communication has been confirmed by all parties involved
2. If all communications systems fail, all bunkering operations should be suspended immediately and not resumed until communications have been re-established.
3. Equipment for non-verbal communication should be robust and reliable. The signs and symbols to be used should be agreed by all parties before bunkering begins.

4. The electrical components of the communication system located in hazardous and safety zones should be type-approved, according to applicable codes or standards.
5. Portable communication equipment, such as radios, which are be used during the bunkering operation should be Ex-rated and suitable for use in the hazardous areas or safety zone.
6. Before operations begin:
   a. the language to be used during the bunkering process should be agreed between all parties
   b. agreed working channels for communication should be tested

7.4.1.3 Leak-detection systems

1. The fixed gas detection system should be checked and confirmed as "Operational and Ready to Use".
2. Any temperature sensors used for leakage detection are to be active and confirmed to be "Operational and Ready to Use".
3. Where fitted, fixed oxygen detection systems should be checked and confirmed as "Operational and Ready to Use".

7.4.1.4 Cryogenic protection

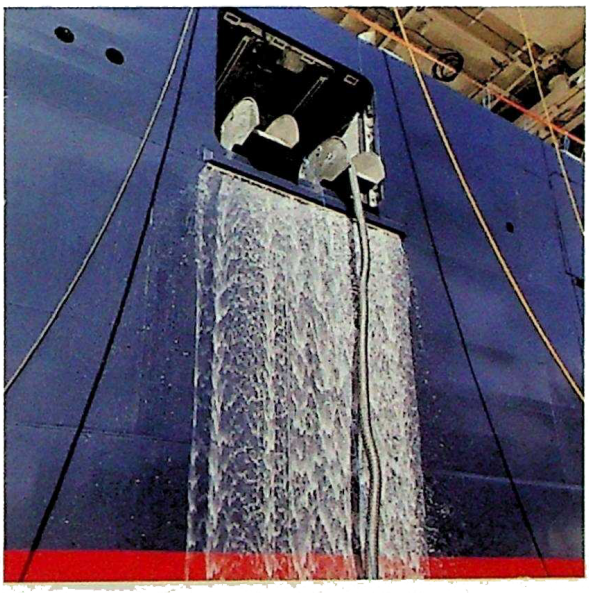
1. Protection of the receiving ship deck and structure from cryogenic brittle fracture caused by leakage of LNG should be fitted as per the requirements of the IGF Code and the approved design.
2. Before bunkering commences and for the duration of the bunkering operation:
   a. drip trays and/or gutters should be in position and empty
   b. drip tray drains and overflow protection arrangements (if any) should be in place, as per the approved design
   c. water curtains whenever possible or alternatively dedicated insulating blankets should be deployed. Where used, they should be activated or in place before the bunkering system is connected and until it is disconnected

7.4.1.5 Bunker hoses – connectors/couplings – supports/saddles

Refer to Section 6.7.1

1. The bunker hose(s) and connectors/couplings that will be used should be removed from storage, inspected and confirmed as "Operational and Ready to Use". The bunker system or part of the bunker system may be pre-assembled at this stage. This may include the ERC discussed in Section 7.4.1.6.
2. The hose supports and saddles that will be used should be installed, secured in position and "Operational and Ready to Use".
3. Any other lifting gear and equipment such as straps, hose buns, and so on should be now inspected, prepared and "Operational and Ready to Use".
4. Inspection of hose(s), connector(s) and support(s) should confirm that:
   a. there are no signs of damage or wear and tear
   b. all items have been maintained and tested

Figure 7.4: An example of water curtain and saddles deployed during bunkering operations (Picture courtesy of Ponant)



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7.4.1.6 Emergency Release System (ERS)

1. The ERS should incorporate a passive or active Emergency Release Coupling (ERC). Before bunkering begins, these are to be prepared and may be connected/pre-assembled to the bunker transfer system.
2. Prior to installation, ERCs should be checked to be clean from dirt and moisture, and surfaces should be blown dry using dry compressed air or nitrogen.
3. Testing of the system prior to each bunkering operation should prove that all components are in satisfactory condition and "Operational and Ready to Use", however, the ERC should not be physically activated.
   a. the link within the ERS and ERC systems and the ESD-1 trip circuit should be tested and proved to be "Operational and Ready to Use"
   b. the link within the ERS and active ERC systems and the ESD-2 trip circuit should be tested and proved to be "Operational and Ready to Use"
4. For an **Active Emergency Release Coupling**:
   a. simulated testing of the ERC should be performed, according to the manufacturer's instructions and recommendations
   b. testing records should be retained by the bunkering system operator or organisation responsible for such equipment, ready for immediate inspection by authorities
   c. any transfer/support system should be inspected for damage, wear and tear and confirmed as acceptable as part of the bunkering checklist
   d. step-by-step operating instructions should be available and all personnel involved in its operations should be trained and made familiar with correct use
   e. clear procedures should be in place identifying the process for authorisation to manually activate the ERC by ESD-2
5. For a **Passive Emergency Release Coupling** ("dry break-away"):
   a. the dry break-away coupling and associated supporting arrangements should be installed in the transfer system in line with the approved bunkering system design
   b. any transfer/support system should be inspected for damage, wear and tear and confirmed as acceptable as part of the bunkering checklist
   c. before bunkering begins, a visual inspection is to be carried out to confirm that the coupling is "Operational and Ready to Use"

7.4.1.7 ESD system-independent functionality test

1. The bunkering facility/supplier and gas-fuelled vessel ESD systems should be independently tested during the preparation phase. The aim of this testing is to establish that the ESD valves will close automatically on emergency shutdown initiation within the set time. It is not necessary to check each and every input to the system before every bunkering operation. It is, however, recommended that all inputs and outputs are tested over time, in line with manufacturer recommendations.
2. The independent functionality test of the gas-fuelled vessel and bunkering facility/supplier systems should be successfully passed by both BSL main and back-up systems, if a backup system is employed, before bunkering begins.
3. Detailed guidance on ESD systems testing can be found in the SGMF publication *Recommendations for linked emergency shutdown (ESD) arrangements for LNG bunkering – TGN06-05*.

7.4.1.8 Electrical isolation/bonding

Refer to Section 6.7.4.

1. The electrical isolation arrangements are to be in place before bunkering begins.
2. Impressed Current Cathodic Protection (ICCP) systems should be disengaged.
3. Where required, bonding cables are to be connected and engaged before bunkering begins.

7.4.1.9 Lighting

1. Sufficient lighting should be provided to illuminate the bunkering operation working areas.
2. It is recommended that fixed and permanent lighting is provided to adequately illuminate the bunkering operation work area, especially:
   a. the LNG transfer system
   b. connections and couplings on both receiving ship and bunkering facility
   c. ESD system call points
   d. communication systems

e. firefighting equipment
f. passageways/gangways intended to be used by the personnel in charge of the bunkering operation

3. When installed in a hazardous zone, lighting should comply with applicable hazardous zone equipment requirements.

7.4.1.10 Firefighting systems

1. Any fixed firefighting system on the receiving vessel or bunkering facility should be checked and confirmed as "Operational and Ready to Use" before bunkering begins.
2. Any portable firefighting equipment is to be checked and found to be in date and located and rigged such that it is easily accessible, and confirmed as "Operational and Ready to Use" in an emergency.

7.4.2 Operational steps and activities – bunkering preparation

During this phase, operational steps and activities are undertaken to confirm that "Bunkering can go ahead". Key activities have been considered in the following sections.

7.4.2.1 Personnel on duty

1. All personal on board the gas-fuelled vessel, within the bunkering facility, and, if applicable, the terminal, are to be made aware that LNG bunkering is due to take place.
2. During the bunkering operation, personnel in the control station, bunker station and safety zone should be limited to only essential staff.

7.4.2.2 Environmental conditions

1. The environmental conditions – weather, including lightning, sea state, temperature, wind speed, current/tidal conditions, and visibility limitation, such as fog or mist, snow and heavy rain – should be acceptable in terms of safety for all the parties involved and within the operational limits of the transfer system and moorings.
   a. conditions should be monitored for the whole duration of the transfer
   b. predetermined limits defined in the compatibility study should be adhered to

7.4.2.3 Fuel and supply system cool-down

1. As far as is practical, the piping at the gas-fuelled vessel fuel system and the bunkering facility system may be inerted and cooled down prior to the connection.
2. If this operation could cause any specific hazards when connecting the bunker system to the manifolds, it should be carried out after the connection has been made.

7.4.2.4 Mooring and securing

When **Mooring** the gas-fuelled vessel and, where applicable, the LNG bunker vessel or barge:

1. It is the responsibility of the master to ensure the vessel is securely moored to the shore and/or to an LNG bunker vessel in line with agreed/approved mooring plans.
2. Masters should follow their approved standard procedure for mooring; additional provisions need to be considered for safe LNG bunkering operations. Mooring arrangements for LNG bunkering should be part of the compatibility assessment (see Section 3.7).
3. Specific mooring considerations for LNG bunkering operations include the following:
   a. it is good practice to avoid locating mooring lines and fenders under the bunker transfer system and within its range of operation
   b. where mooring lines and fenders are required to be located under or close to the bunker transfer system, they should be protected from cryogenic damage
   c. the mooring arrangement should:
      i. aim to prevent excessive relative movement during the whole duration of the bunkering operation
      ii. be regularly adjusted to accommodate change of draft due to the transfer of fuel
   d. the emergency mooring release procedure should be agreed between the bunkering facility and the gas-fuelled vessel before bunkering starts

When **Securing** the LNG delivery truck or tank containers in mobile-to-ship bunkering supply scenarios:

1. The LNG truck or portable tanks should be securely parked or positioned to prevent unintended or accidental movements.
2. When the LNG truck has been secured, the engine should be switched off and the keys removed until the transfer system is disconnected. If the truck's engine is required to run to drive the pump, additional measures should be taken to secure the truck by applying the brakes, or clamping the wheels.
3. The parking or positioning of LNG truck and portable tanks on the quay side should:
   a. consider all ignition sources linked to the truck or portable tank that should be managed in accordance with the bunkering management plan/procedure, taking into account hazardous areas and safety zones
   b. consider operations where multiple trucks or portable tanks are sequentially connected and disconnected to bunker a vessel and how these are driven into and out of the safety zone
   c. not interfere with the range of movement of the hose being pulled or stretched in case of an emergency scenario in which the vessel drifts away

Mobile-to-ship operations often employ a passive ERC (see Section 4.6.2), which requires a positive force to be applied to the hose, the ERC and the trucks' or portable tanks' manifold for ESD-2 disconnection of the bunker system. This force can be of the order of several hundred kilograms.

7.4.2.5 Safety and controlled zone mark-out

1. The boundaries of the safety zone and controlled zone associated with the bunkering operation should be clearly marked out (see Section 3.3).
2. Marking of safety zone and controlled zone may be achieved by erecting signs or physical barriers. The suitability of marking should be agreed between the parties during the operational risk assessment (see Section 5.6).
3. Access to the safety zone should be limited to required and trained personnel only and controlled at all times.

4. All other portable equipment in use should be hazardous area certified or secured outside the hazardous areas. Safety zone access control should monitor the entry into the safety zone of non-EX-rated certified equipment that is not suitable for use in the hazardous areas and which may be carried by personnel. This can include personal phones, smart watches and so on.
5. Electrical equipment installed in a safety zone that is not certified for the operation should be electrically isolated before the bunkering operation begins, and throughout the bunkering process, until the area is free of any gas leak hazard.

Figure 7.5: Sign located at the entry of the bunker station on board an LNG-fuelled vessel (Picture courtesy of DEME Offshore)

7.4.2.6 Visual inspection before physical connection

1. A visual inspection of the bunkering equipment and layout should be carried out by the PICs or deputy before deploying and connecting the bunker system:
   a. bunker hoses and connecting systems – including flanges, coupling and coupling seals – should be visually examined for wear and tear, physical damage and cleanliness
2. If any defects are found during this inspection, the bunkering operation should be postponed until the deficiency is rectified.

7.4.3 Bunkering agreement and checklist signed off

The following activities may be completed during a "pre-bunkering meeting". This may be a face-to-face or virtual/phone meeting, if agreed and accepted by both the receiving ship operator and the LNG bunkering organisation. Face-to-face meetings are recommended as a minimum in the case of new operations, if notable changes are introduced in an ongoing well established bunkering procedure, or if a lesson learned needs to be discussed/implemented.

7.4.3.1 Agreement of the transfer conditions

1. The following should be agreed and confirmed by the supplier and receiver PICs at the pre-bunkering meeting:
   a. transfer time, temperature and pressure of the delivered LNG, pressure inside the receiving ship's tank, delivery line measurement, and vapour return line measurement (if any)
   b. liquid levels, and temperature and pressure for the LNG bunker tanks of the bunkering facility
   c. the maximum loading level and transfer rate – including cool-down, ramp-up, required flow rate and topping-up – should be agreed, including the pressure capacity of pumps and relieving devices in the connected transfer system (ref IGF Code 6.8).
2. Transfer conditions should not exceed the agreed parameters in the LNG bunker management plan. Values should be recorded in the IAPH checklist.

7.4.3.2 Bunkering checklist

1. Supplier and receiver PICs are responsible for the completion of each organisation's bunkering checklist, or, when agreed, the mutual checklist, to prepare the vessel, bunkering equipment, bunkering facility and personnel for bunkering
2. Applicable parts of the bunkering checklist should be completed and signed off by the LNG bunkering organisation's and the receiving ship operator's PICs before the next phase of bunkering begins.

Lessons Learned 7-1: *Preparing for the Bunkering Phase*

The following list is a collection of considerations and tips that may be used by the LNG bunkering organisation and the receiving ship operator during preparation of the bunkering equipment and safety systems.

1. **Gloves suitable for the low-temperature parts of the personnel's PPE equipment should be worn in line with whether the location of the connection is above or below shoulder height.** If the connection is below shoulder height, the gauntlet gloves should be tucked INSIDE the jacket sleeves. If the work is carried out above shoulder height, the gloves should be worn OVER the jacket sleeves. In the unlikely event of a spill, this minimises the likelihood that cryogenic liquid will enter the gloves.
2. **Communication between supplier and receiver may be achieved by various means, so long as it is deemed direct, reliable and clear by both parties:**
   a. direct face-to-face communication may be acceptable in small-scale operations of short duration, so long as the personnel involved are assuming a control role and are not directly involved or distracted by the operation or by other distractions, such as noise
   b. unless suitably adapted for use in hazardous areas or within a safety zone, mobile or smart phones should not be used, as they can be a source of ignition; in addition, SGMF suggests they are not used as a general means of communication because they can be distracting and are not a direct and exclusive form of communication for the bunkering operation

3. **Drip trays should be in place to provide protection in case of LNG leakage.** They should:
   a. be empty and NOT filled with water
   b. have a draining and overflow system so that in case of leakage the LNG is released into a safe area – for example, overboard at water level. Drains should be deployed/opened and free of blockages
4. **The following considerations apply to bunker hoses and couplings:**
   a. they should be stored with caps or blank flanges when not in use to prevent ingress of moisture and dirt. In the case of composite hoses this prevents the escape of gas that is naturally retained in small quantities between the composite layers of the hose. Removal of such caps or blank flanges should be delayed until the final moment of connection
   b. before removing a blank flange from any type of hose (whether composite or not) it is good practice to check whether there is internal residual positive pressure due to the presence of gas, and they should be removed accordingly
   c. if it is not possible to check the internal pressure of the hose, it should be assumed that both gas and a positive pressure are present
5. **The LNG bunkering organisation and the receiving ship operator should ensure that the personnel on duty are properly trained, not only for the operation itself but also to identify and recognise risks or threats arising:**
   a. Personnel should understand their duty to stop the operation if risks or threats are identified, without the fear of being blamed
   b. the LNG bunkering organisation and the receiving ship operator should promote a proactive response from their personnel on duty in case of emergencies
6. **The required number of personnel on duty during a bunkering operation should be agreed between the LNG bunkering organisation and the receiving ship operator (See Chapter 6.4) considering and proportionate to:**
   a. the complexity of the bunkering operation and the number of organisations involved
   b. the location and how the safety zone and SIMOPS impact the operation and/or neighbours

   Where possible, it is suggested that two personnel should be present at the bunkering facility and the gas-fuelled vessel for the duration of the bunkering operation, in case one becomes incapacitated.

7. **The cooling down of the gas-fuelled vessel's fuel system and the bunkering facility's supply system prior to connection of the bunker system during the preparation for bunker phase is primarily a time-sensitive matter that can help reduce the amount of time the two parties spend alongside**:
   a. cool-down operations during the preparation phase depend on the configuration of the gas-fuelled vessel's fuel system and the bunkering facility's systems, equipment and BOG generation, and the ability to handle it without release to atmosphere should be also considered. Different configurations allow different levels of pre-cool prior to hose connection
   b. the cool-down rate is subject to the maximum allowable cool-down rate of each component of the bunkering line
   c. whenever possible, it is suggested to at least start the independent cooling down of the fuel and supply systems during the preparation phase
      i. cool-down at this point should typically include pumps and main headers
      ii. It is not recommended in this phase to cool down the bunkering line up to the last manifold valve, such as the ESD manifold valve
   d. a full independent cool-down of the fuel and supply systems prior to connection of the bunker transfer system does not remove the need to cool down the full connected bunkering line (for example, hoses, manifold connection, couplings and so on) in the next phase

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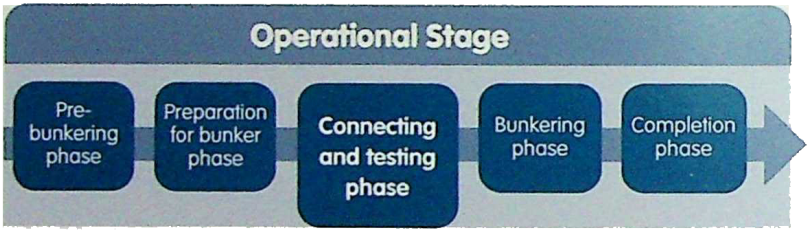
7.5 Bunker Transfer System Connection and Testing Phase

Note
The bunker transfer system connection and testing phase starts from the deployment of the bunker transfer system through connection to the manifold, and testing and terminating before any gas is passed through the bunkering line.

This phase aligns with Part C of the IAPH checklist for items and questions not completed in the previous phase (see Section 3.6).

Goal
The goal is to safely transfer and connect all the equipment required to undertake LNG bunkering and to ensure all equipment is in working condition before the transfer of cryogenic liquid begins.

Key activities/steps



Key activities/steps:
1. Pre-connection checking and preparation are carried out.
2. The bunker transfer system is deployed and connected.
3. Bunkering lines are purged, safety ESD and ERS systems are armed, and connections are tested for leaks.

Considerations and recommendations

1. Steps and activities during the connection and testing phase should be led and directed by the appointed PIC acting in the POAC role.
2. The LNG bunkering organisation and the receiving ship operator should, according to operational requirements:

a. tailor the following steps and activities recommended to be undertaken and completed in this phase
b. include any specific activities that depend on equipment, bunkering supply scenario and location

7.5.1 Pre-connection checking and preparation

7.5.1.1 Hose bunker system preparation

1. Before the hose bunker system is connected to the receiving manifold:
   a. hoses should be suitably supported during transfer and connection so that the manufacturer's minimum acceptable bending radius is not exceeded
   b. equipment utilised with the transfer system – such as hose rests, saddles, and guidance systems (as applicable) – should be suitable and fit for purpose
   c. the Emergency Release System (ERS) governing the activation of the ERC should be set as "disarmed" to prevent inadvertent activation during connection
2. Where applicable, suitable protection should be provided to avoid damage from friction on the quay or deck, handrails, etc.
3. Detailed guidance on how to handle and manoeuvre hose bunker systems during all phases of bunkering can be found in the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06.*

7.5.1.2 ESD system preparation

1. Before the ESD system and the BSL are deployed and connected, the supplier ESD system should be set as "master" (ref: TGN 06-05, Ver1.0 § 4.3).

7.5.1.3 Manifold preparation

1. Before removing any cap or blank flange from the manifold of the bunker transfer system connectors or flanges:
   a. the pressure in all lines to be connected should be confirmed as zero or negligible
   b. all bunker station manifold valves should be closed, and the bunker manifold isolated

2. If connection is achieved by flange-to-flange, it should be ensured that before removal of any cap or blank flange the following are available for the next stage of connection:
   a. nuts and bolts of correct material and specification
   b. gasket or seals of correct material and specification
   c. any tool required for the connection

7.5.1.4 Condition of flange and connectors prior to connection

1. During connection of the bunker transfer system, humidity at the flange or connector mating surfaces should be avoided and all mating surfaces should be clean, undamaged and free of debris.
2. Dry compressed air or nitrogen should be used to clean the contact surfaces of flanges or connectors and seals before physical connection:
   a. immediately prior to connection, the manifold presentation flange or connector on the receiving vessel should be checked to ensure that gaskets or seals are in place, complete and undamaged
   b. heating of coupling connections to ensure they are free from ice prior to connection may be considered in some circumstances
3. Where compression gaskets are required between flanges, it is recommended that these are of the anti-blow-out type and used for only one operation.

7.5.2 Bunker transfer system deployment and connection

1. The bunker transfer system should be deployed and manoeuvred from the supplier to the receiver according to the bunkering procedures and safety instructions in the LNGBMP.

   The followed may be deployed, as applicable (though the order of deployment may vary):
   a. ESD drifting lines/limits (ref: TGN06-05, Ver 1.0 § 2.5.3 and TGN06-06, Ver 1.0 § 4.3.2.1)
   b. BSL umbilical cable/hose (ref: TGN06-05, Ver 1.0 § 3)
   c. fall-arrest system (where applicable) (ref: TGN06-06, Ver 1.0 § 5.3.4)
   d. hose bunker system, loading arm or hybrid system
   e. nitrogen-purging line

2. The deployment of the bunker transfer system and associated equipment should be undertaken in line with agreed handling procedures to avoid risking the health and safety of those involved, where applicable:
   a. there should be sufficient slack in cables, links, and hoses to prevent snagging or damage during deployment
   b. care should be taken to avoid short circuiting lifting lines that can choke hoses and cables (ref: TGN06-06, Ver 1.0 § 5.2.1)

FIRST, CHECK YOUR LIFTING GEAR

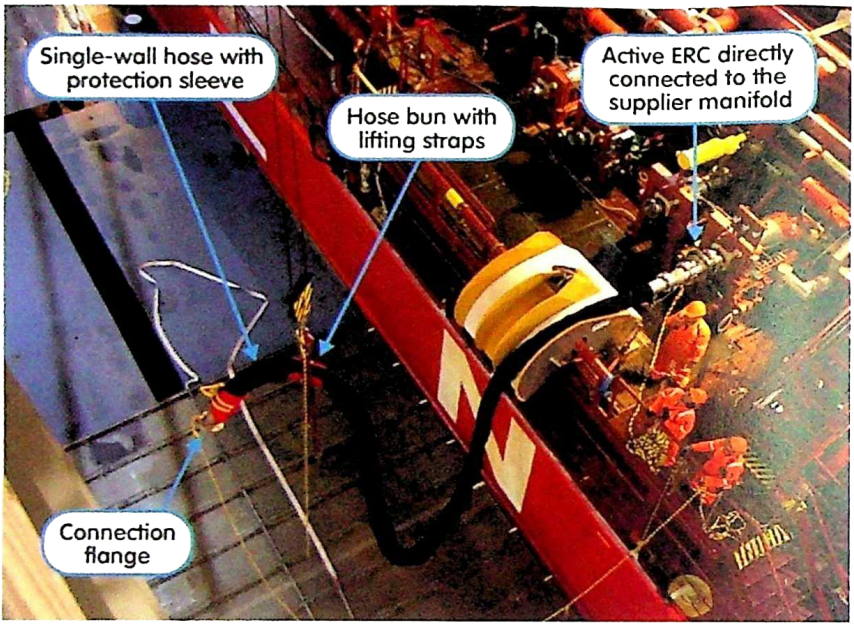
The handling and manoeuvring of hoses or a hose bunker system is primarily a lifting operation.

Make sure that all lifting equipment is suitable for the job by checking, as a minimum, the SWL and reach required.

Hose lifting should follow the same procedures as any other lifting operation, using certified and tested equipment and carried out by trained personnel with appropriate PPE.

3. After being manoeuvred into position, the bunker transfer system and associated equipment should be connected to the receiving vessel according to the bunkering procedures and safety instructions in the LNGBMP. The order of connection may vary by application:
   a. good practice and lessons learned for hose bunker system connection, flange-to-flange or DD/CC can be found in the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06*
   b. it is good practice to connect and test BSL umbilical cable/hose and ESD drifting lines/limits as part of the ESD safety system before the hose bunker system, loading arm or hybrid system is connected to the manifold presentation flange (see Section 7.5.3.1)

Figure 7.6: An example of a hose bunker system during deployment (Picture courtesy of SGMF)



7.5.3 Connection – purging and testing

7.5.3.1 ESD and ERS system testing

1. The ESD system and the ERS system, of which the ERC is a part, are safety-critical components of the bunker system. A set of tests is typically required before bunkering begins (the tests are listed below, with further recommendations provided in Lessons Learned 7-2: ESD and ERS System Testing Steps):
   a. **ESD System – Linked Functionality Test**
      The newly linked ESD systems are tested together – with communication signals exchanged between the bunkering facility's ESD system and the gas-fuelled vessel's ESD system – to check compatibility.

b. **Warm ESD-1 Testing**
An ESD-1 signal is exchanged to and from the bunkering facility and the gas-fuelled vessel to test emergency shutdown functionality.

c. **Emergency Release System Testing And Arming**
The ERS system functionality to activate an active ERC is tested, or safety pin removed from passive ERC.

2. The ESD system and the ERS system are two independent components of the bunker transfer system. They are typically connected, but are controlled by an independent control system, the functionality of which needs to be tested before bunkering.

***Lessons Learned 7-2:** ESD and ERS System Testing Steps*

The following provides an overview of the required testing for the ESD and ERS systems.

1. The testing procedure for each system can vary significantly depending on the technology used and the manufacturer:
   a. the LNG bunkering organisation and the receiving ship operator should refer to their systems' manuals to define the testing procedures required
   b. if handheld pendants are used in the operation, procedures should include their testing
2. The following tests should be successfully passed by the connected gas-fuelled vessel and bunkering facility systems before bunkering begins. Tests may be combined, or their order changed, depending on the systems employed or their configuration.

ESD System – Linked Functionality Test

1. After the BSL umbilical cable/hose connection is made, and as far as practical before connection of the bunker transfer system to the manifold, the linked functionality test should be carried out to demonstrate the functionality of the linked ESD system.
2. The test should demonstrate, as a minimum, for the gas-fuelled vessel's and bunkering facility's systems that:
   a. power supply is present
   b. communications between the bunkering facility's ESD system and the gas-fuelled vessel's ESD system are established and compatible

3. Detailed guidance on ESD systems testing can be found in the SGMF publication *Recommendations for linked emergency shutdown (ESD) arrangements for LNG bunkering – TGN06-05.*

Warm ESD-1 Testing

1. Following the completion of the bunker transfer system manifold connection, the linked ESD system should be armed and the emergency shutdown signal exchange time from the supplier to the receiver tested.
2. Testing should take place between the receiving ship and the bunkering facility prior to commencement of the operation (warm ESD-1) to confirm that the systems are correctly connected, and that the emergency shutdown signal is exchanged:
   a. initiation of the warm ESD-1 signal can be made from either the receiving ship or the bunkering facility, but should be confirmed and agreed
   b. ESD valve closure times on both installations should be noted and recorded, with confirmation that closure takes place in both ways within the set design time

Emergency Release System Testing and Arming

1. Once testing of the ESD system is complete, any devices required to support the separation of the Emergency Release Coupler (ERC) should be tested and armed, as applicable. The Emergency Release System should be tested according to the manufacturer's instructions to confirm it is functional and armed.

7.5.3.2 Bunkering line purging

1. After connection of the bunker transfer system, the bunkering line should be purged to ensure that oxygen and humidity inside are reduced within acceptable levels:
   a. nitrogen should be used to purge any parts of the system where LNG or vapour may be present during the bunkering operation
   b. nitrogen may be supplied by the bunkering facility, the gas-fuelled vessel or both.

i. the bunkering facility typically has greater nitrogen production capability and is usually considered the primary source of nitrogen during bunkering
ii. the gas-fuelled vessel should, as a minimum, have enough nitrogen production capability or storage to purge its own piping system

2. A typical purging sequence of the transfer line involves the injection of about three times the volume of the bunker line at 4-5 barg
3. The atmosphere in the bunkering line should be sampled to ensure purging is complete:
   a. samples should be taken at both the supply and receiving manifolds (see Figure 4.2)
   b. typically, purging is considered to have been achieved when both samples show values not exceeding 2% by volume of methane

7.5.3.3 Bunkering line pressure-leak testing

1. A leak test should be performed before any bunkering operation at each connection point and flange, starting from the manifold flange of the bunkering facility to the manifold flange of the receiving vessel. This typically includes spool pieces flanges, hose flanges, connectors, DD/CC, instruments connections (if any), ERC flanges and so on.

   Further recommendations provided in Lessons Learned 7-3: Connection and Testing Phase

Lessons Learned 7-3: *Connection and Testing Phase*

The following list is a collection of considerations and tips that may be used during the connection and testing phase. They are collected here for information and reference for the LNG bunkering organisation and the receiving ship operator.

1. During the connection phase of hose bunker systems, some LNG bunkering organisations prefer to have a slightly positive pressure up to 1 barg inside the hose. This is achieved using inert gas. This practice is used to further limit moisture entering the hose during the connection phase:
   a. this practice may be suitable if the time between removing flanges or caps from the hose bunker system to the moment of connection is limited to a few minutes
   b. personnel removing flanges or caps from the hose bunker system and connecting it should be made aware of positive nitrogen pressure in the hose
2. Bunkering facilities and gas-fuelled vessels should be aware of the nitrogen supply requirement for purging the whole bunkering line, including the bunker transfer system, and plan operations accordingly:
   a. enough nitrogen should be available to inert the whole length of the bunkering line. This is likely to be up to about three times its volume
   b. a personal mobile oxygen monitor as additional PPE might be required before removing flange caps from the hose bunker systems

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Great care must be exercised to ensure the safety of all personnel involved in any operation using inert gas of any description to avoid asphyxiation due to oxygen depletion.

Ensure proper warning labels are placed in highly visible areas, and crew are trained on asphyxiation hazards associated with nitrogen.

3. Bunkering line pressure-leak testing procedures can vary, depending on the bunker transfer system equipment used. The pressure-leak testing aims to identify any potential leak after the connection of the bunker system that might occur at flange connections, gaskets, and seals. The following is suggested as a general approach for the testing of a bunker system:
   a. pressurise with nitrogen, initially at 200 mbar
   b. pressurise at the maximum agreed pressure of the bunkering operation, typically 5 barg or above
   c. this should be held for no less than 5 minutes
   d. the bunkering connections should be inspected for leaks with the use of soapy water
   e. acceptance criteria recommendations – if a leak is detected during the testing up to the maximum agreed pressure of the bunkering operation, operations should be stopped, and leak issues rectified before proceeding.

Note

Where it is not possible or practical to perform the pressure-leak testing at the maximum agreed pressure of the bunkering operation, the LNG bunkering organisation and the receiving ship operator can agree to perform the pressure-leak testing at a lower value, generally between 4 to 5 barg, typical of the onboard nitrogen supply equipment.

Pressure-leak testing at lower pressure can be agreed to be sufficient to check for leaks at the connections points of the bunker system and to allow later LNG transfer at the full bunkering pressure. Furthermore, operators should monitor the bunker system connections for leakage during the whole operation. In particular, during and after the cooling down of the line, when due to the material's shrinkage at cryogenic temperature, connections might become loose and need to be readjusted/tightened.

   f. additional guidance on the testing of hose bunker systems can be found in the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06*

7.5.4 Checklist completion

1. At this point, all checklists – IAPH Parts A, B, C and D – should have been completed and both parties should have agreed that everything is ready for the transfer of LNG.
2. Notification to the local authority with jurisdiction over the bunkering location that the LNG transfer is due to start may be required before the next phase begins.

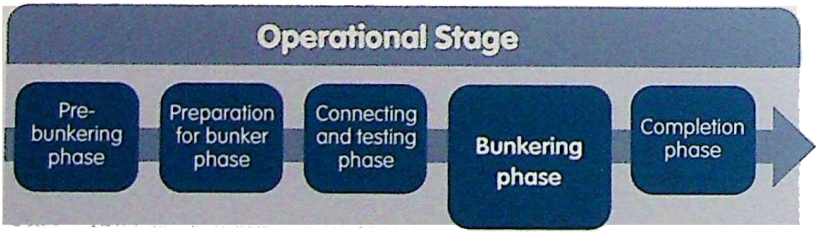
7.6 Bunkering Phase

Note:
The bunkering phase begins after the physical connection between the bunkering facility and the receiving ship's bunker station has been safely completed. It starts with the cooling down of the transfer line, followed by the LNG bunker transfer, and finishes at the end of the topping-up/ramp-down phase.

This phase aligns with Part E of the IAPH checklist for items and questions not completed in the previous phase (see Section 3.6).

Goal
The goal of the bunkering phase is to manage people, equipment and procedures to ensure a safe transfer of the agreed quantity of fuel from the supplier to the receiver vessel.

Key activities/steps



Key activities/steps:
1. Bunkering line preparation and conditioning prior to transferring LNG.
2. LNG bulk transfer and process management.

Considerations and recommendations

1. Steps and activities during the bunkering phase should be led and directed by the appointed PIC acting in the POAC role.
2. During the whole bunkering phase, a suitable and operational ESD and ERS system should be active.
3. After connection of the bunker transfer system, a suitable cool-down procedure should be carried out in accordance with the specifications of the bunkering equipment and the receiving tank supplier's requirements.
4. Flash gas or boil-off gas should not be released to the atmosphere during normal bunkering operations.
5. The condition of bunker lines, transfer systems, and receiving and supply tanks should be continuously monitored for the duration of the bunkering phase.
6. The LNG bunkering organisation and the receiving ship operator should, in line with actual operational requirements:
   a. tailor the following steps and activities recommended to be undertaken and completed in this phase
   b. include any specific activities that depend on the equipment, bunkering supply scenario and location

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Figure 7.7: An example of an STS bunkering operation
(Picture courtesy of Harvey Gulf International Marine and Carnival)

7.6.1 Bunkering line preparation and conditioning

7.6.1.1 Bunkering system line-up

1. Following the connection and the authorisation to transfer LNG, the LNG supply system, the bunker transfer system, and the receiving fuel system should be set with lines open to the LNG tanks. The open/close status of valves and the instrumentation in the bunkering line should be set ready to route the LNG to the intended tank.
2. Any additional gas-consuming equipment needed for BOG management should be available and on line if required. Where in use, the vapour return line should be lined up.

7.6.1.2 Bunkering line cool-down

1. Cooling down of the bunker transfer system, supply and receiving manifolds and tank lines should be carried out using a small flow of

LNG, according to equipment requirements (e.g. temperature rate limits) and the bunkering procedure. Special care should be taken:

a. to watch for potential leaks that may occur as components shrink as they are cooled
b. to monitor over-pressurisation that may occur if the cool-down process generates excessive gas due to evaporation
c. pump(s) used to deliver the required pressure for the tank to be filled should be cooled to the operating temperature before starting. This may be achieved by filling the pump circuit with liquid from the tank (as some pumps, cool-down can take few hours. This should start during the Preparation Phase, see Section 7.4.2.3)
d. part of the bunkering line and equipment may already have been cooled down in the Preparation Phase (see Section 7.4.2.3)

2. Connections to the bunkering facility and the receiving ship should be monitored and checked and, if necessary, LNG flow should be stopped to allow fittings to be tightened.

7.6.1.3 Cold ESD testing

1. Following the successful completion of cool-down operations, the cold ESD test should be carried out to ensure that the ESD valves operate correctly in cold conditions before initiating the main LNG bunker transfer.
2. It is acceptable to initiate a "stroke test", where both ESD valves are closed on demand without the activation of an ESD-1/bunkering ESD, so long as a warm ESD test has been undertaken with a full ESD-1.

Lessons Learned 7-4: *Cool-down considerations*

The following list is a collection of considerations and tips that may be used during the cool-down of the bunkering line. They are collected here for information and reference for the LNG bunkering organisation and the receiving ship operator.

1. **During cool-down, avoid opening or closing valves too rapidly, or suddenly increasing or decreasing pressure.**
2. **Uneven cooling of materials may cause (temporary) relative deformations which, in turn, may lead to leaking connections, especially in large-diameter piping and hoses.**

3. **The following provides typical methodologies for cooling down the bunkering line.** Each operation should be tailored according to specific system requirements:
   a. slowly open the discharge valve on the bunkering facility. This allows the pressure in the piping system on the supplier side to equalise with that in the gas-fuelled vessel's piping system and fuel tank
   b. if the pressure in the piping system on the supplier is lower than the receiver, then the bunkering facility's offloading pump will run at a lower rate to overcome the pressure difference
   c. only when the bunkering line has reached the agreed temperature and the system has been confirmed as leak free should the pumping rate be ramped up to achieve a gradual cool-down. Temperature readings may be taken at the supplier and receiver manifolds
   d. manifold connection and piping and some types of non-insulated hoses can form an external layer of frost. This is often regarded as a sign that the bunkering line has cooled to the correct temperature – however, frosting is not a reliable indicator of temperature

Lessons Learned 7-5: *Fuel Tank Temperature Monitoring*

A key parameter for defining the most appropriate initial bunkering flow rate is the temperature of any LNG left in the receiving vessel's tank(s). It is therefore vital for the bunkering facility to have a clear understanding and reliable information about the temperature of the receiving tank(s)'s so that their temperature and pressure can be kept under control during the operation, and the amount of flash gas from the LNG vaporisation minimised.

While it is recommended to have temperature sensors in the fuel tank(s), it should be noted that this is not an IGF Code statutory requirement for type C tanks with vacuum insulation (ref IGF Code § 15.4.11). Furthermore, the lack of a unified industry-wide approach to the installation, number, and location of temperature sensors as well as the technical challenges of having temperature sensors in vacuum isolated type C tanks, has led to the use of different means of obtaining tank temperature readings. These might be from direct instruments/sensors or from using LNG temperature-pressure relationship curves.

LNG temperature-pressure relationship curves are based on the tank pressure and an indicative LNG composition. If the LNG has been in the tank for some time, it will weather, and its composition may change significantly from the reference values. At this point, temperature-pressure relationship curves become unreliable and may significantly overestimate the coldness of the LNG tank.

The information about the temperature of any LNG left in the receiving vessel's tank(s) can range from approximate (if the temperature is measured by a sensor within the lower part of the tank) to inaccurate (if estimated using LNG temperature-pressure relationship curves). Particularly in this latter case it can lead to errors in the way a tank is loaded.

For example, one incident report noted that when cold LNG was being loaded into an unexpectedly warmer tank, a larger than anticipated volumes of flash gas were generated which was sufficient to cause venting from the tank to the mast, generating a gas cloud over the gas-fuelled vessel and bunkering facility.

Bunkering facilities and gas-fuelled vessel ship owners and operators involved in bunkering operations should consider the following points:

1. As part of the bunkering compatibility assessment or during the pre-bunkering meeting, the parties should discuss and check whether the reported receiving vessel tank temperature has been obtained by a direct reading or estimated using LNG temperature-pressure relationship curves.
   a. Both PICs should be aware that the use of the LNG temperature-pressure relationship could result in inaccurate temperature estimation.
2. In cases where the reported temperature of the receiving vessel's tank is deemed unreliable:
   a. Initial bunkering flow rates should be reduced as a precaution.
   b. Rigorous monitoring of the tank pressure at the beginning, as well as during the whole bunkering operation, is recommended for all parties.
   c. If the pressure of the receiving vessel's tank is high, and this is combined with a low fuel level from a bunkering some time ago, the parties should consider having the bunkering operation performed

by a bunkering facility suitably equipped to handle a large quantity of vapour return and able to facilitate a possible tank cooldown.
3. Whether breathing apparatus should be included as part of the asset emergency response PPE, to provide protection from a gas cloud dispersing as a result of an emergency venting.

7.6.2 Bulk transfer and process management

7.6.2.1 Main bunker transfer

1. After proper cooling down and leak-checking of the bunkering facility, bunker transfer system and receiving vessel is complete, the bulk transfer can start.
   a. the transfer should start at the agreed ramp-up rate, maintaining a stable condition
   b. the transfer system and manifolds should be checked for leaks during ramp-up. If a leak is detected, LNG flow should be stopped until the leak is resolved
2. The receiving vessel should confirm the correct flow of LNG into the desired tanks and that flash gas generation is in line with BOG management capabilities.
3. Once stable conditions are confirmed, the transfer rate can be slowly increased to the agreed maximum transfer rate, in line with the bunkering procedure.
4. The transfer process should be continuously monitored with regard to the operating limits of the system.
5. If there are any deviations from the agreed transfer or system operating limits of the system, each PIC should immediately flag it to the other party to determine the cause and, if required, stop the transfer of LNG.

7.6.2.2 POAC and PIC supervision

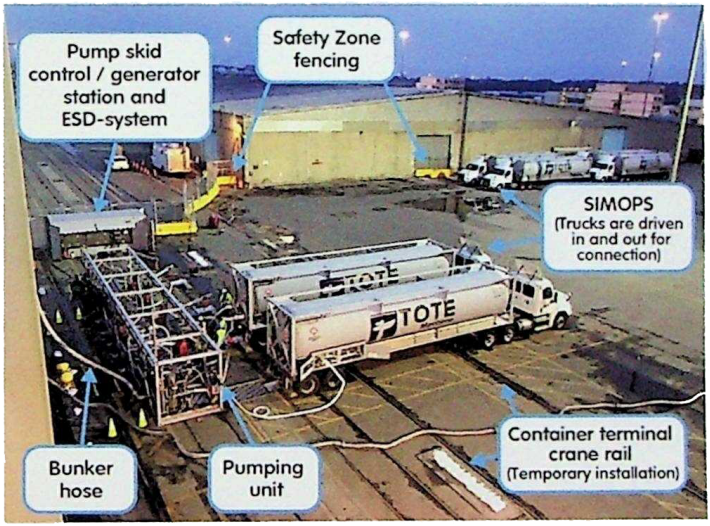
1. Continuous supervision of the bunkering operation and associated installations is required by the PICs and designated individuals. This should include:
   a. visual inspections of the bunkering stations, equipment and surrounding area, either in person or via CCTV
   b. mooring lines should be supervised during the entire bunkering

operation, especially where the relative positions of the bunkering facility and receiving vessel may change

c. the transfer rate should be continuously monitored and changes to valve line-up, when flow is redirected to a different tank agreed before any change (where applicable on a multi fuel tank gas-fuelled vessel)
d. safety zones should be monitored during bunkering

2. Only authorised SIMOPs should be undertaken during bunkering.

Figure 7.8: Mobile-to-ship bunkering operations with multiple trucks (Picture courtesy of Tote Maritime)



7.6.2.3 Process monitoring and checking

1. The pressure, temperature and level of the receiving tank should be monitored and controlled throughout the bunkering process to prevent overfilling and over-pressurisation
   a. the PIC should report the tank and transfer parameters to the bunkering facility regularly at the agreed intervals or as soon as unexpected changes are detected
   b. if the pressure in the tanks rises beyond agreed parameters, additional BOG management may be needed (for example, by an increase in consumption or a reduction in LNG flow rate)

2. During the whole duration of the bunkering phase, arrangements should be in place for repetitive checks of the IAPH checklist.
   a. repetitive checks should be agreed between the PICs before transfer
   b. IAPH items coded 'R' (repeated checks) in the checklist should be re-checked at agreed intervals
   c. any discrepancy or issue during the repetitive checks should be immediately flagged to the PIC and POAC
   d. it is recommended that repetitive check intervals are:
      i. at least 30 minutes to one hour apart, proportionate to the duration of the operation, and/or
      ii. at critical points of the operation – for example, after an agreed change of flow rate, change of LNG route to a different receiving tank, and so on

7.6.2.4 Topping-up of the tank

1. Topping-up of the receiving tank should be carefully supervised by the POAC closely monitoring the filling up of the LNG tank(s).
2. The LNG transfer flow rate should be reduced in line with the agreed plan when the receiving tank LNG level approaches the specified loading limit (unless circumstances have changed during bunkering).
3. The loading limit of the tank and the tank pressure should be paid special attention by the POAC during this operational step. Opening of the tank's pressure-relief valve (PRV) due to overpressure in the tank – for example, following overfilling – should be avoided.

Lessons Learned 7-6: *Rollover*

Mixing is the norm for LNG. Its low viscosity allows mixing to occur without issue in most situations. However, there are specific circumstances where mixing does not occur. If this happens, two or more separate layers of fuel may form, each with its own composition and temperature. If at some point, these layers suddenly mix, the normalisation of their different energies into one uniform mixture can be very rapid.

A rollover occurs when two layers of fluid of different density mix rapidly, resulting in the emission of large quantities of vapour (up to 10 times normal BOG rates).

In most mixing scenarios it is unlikely that the two fuels will create separate layers. The addition of the second fuel volume generally causes disruption in the first fuel volume and mixing will occur naturally between the two fuels. However, this kind of mixing during filling is not guaranteed to occur, resulting in a potentially unstable scenario, called a "metastable rollover".

A metastable rollover can occur if:

- a layer of rich LNG (with a higher concentration of heavy hydrocarbons and therefore of higher density) is placed on top of a layer of lean LNG
- a layer of lean LNG is placed beneath a layer of heavier rich LNG

These two scenarios result in a layer of fluid of lower density beneath a layer of higher density, which is inherently unstable.

Ingress of heat into the tank will cause LNG in the top layer to boil off, keeping its temperature and density constant. However, the lower layer, trapped beneath the upper layer, is not able to boil off vapour, so its temperature will begin to rise. As it warms, its density will decrease.

Eventually, the buoyancy of the lower layer of LNG will be sufficient for it to break through the upper layer of LNG – resulting in a rollover event.

When the lower layer of "warm" LNG reaches the BOG/liquid surface, some of it will vaporise very rapidly until its temperature is similar to that of the other LNG layer. This evaporation leads to large quantities of BOG, sometimes sufficient to damage the structure of LNG tanks. Pressure-relief valves will almost certainly lift, discharging natural gas to the atmosphere, with safety and environmental implications.

The key techniques that help reduce the likelihood of a rollover are:

- ensuring immediate mixing of the two fuels (so there will be a higher initial production of BOG)
- segregating fuels of different compositions by loading them into different tanks
- monitoring boil-off rates – a rapid reduction in boil-off rate may be the precursor to a rollover event

- mixing of different fuel qualities by moving fuel from one storage tank to another

In most scenarios, the LNG heel left in the tank will be rich LNG. Bunkered LNG therefore needs to be filled from the top. Alternatively, as the heel volume will normally be low, a high flow of new LNG into the bottom of the tank should create sufficient turbulence to mix the two LNG volumes together.

Metastable rollovers have occurred in onshore LNG storage tanks and on LNG carriers.

7.7 Bunkering Completion Phase

Note:
The bunkering completion phase begins when the bunker transfer, topping-off and ramp-down have been completed. It ends when all the bunkering equipment has been safely stored, the receiving ship and bunkering facility have safely separated, and all the required documentation has been completed.

This phase aligns with Part E and F of the IAPH checklist (see Section 3.6).

Goal
This phase should ensure safe disconnection and retrieval of the transfer systems from the receiving ship to the bunkering facility, without release of LNG or excess vapour to the surrounding environment.

Key activities/steps

Key activities/steps:
1. Bunkering line inerting and disconnection.
2. Equipment retrieval and storage.
3. Post-bunkering documentation.
4. Unmooring/separation

Considerations and recommendations

1. Steps and activities during the connection and testing phase should be led and directed by the appointed PIC acting in the POAC role, up to the point of the retrieval of the bunker transfer system, after which each PIC will take back the ownership lead of their own side of the operation.
2. The following requirements should be considered during the bunkering completion phase:
   a. draining, purging and inerting sequences should be completed without the release of natural gas to the atmosphere
   b. transfer system equipment should be safely disconnected, retrieved and stored
   c. The unmooring operation and separation of ship(s) is completed
3. The LNG bunkering organisation and the receiving ship operator should, according to operational requirements:
   a. tailor the following steps and activities, recommended to be undertaken and completed in this phase
   b. include any specific activities that depend on equipment, bunkering supply scenario and location

7.7.1 Bunkering line inerting and disconnection

7.7.1.1 Draining, purging and inerting

1. This part of the process ensures that the transfer system is in a safe condition before separation.
2. The details of this process will be design-dependent, but should include the following steps:
   a. shutdown of the supply
   b. draining/removal of any remaining LNG from the transfer system
   c. purging of natural gas from the transfer system and any connections
   d. safe isolation of the supply and receiving tanks
   e. safe disconnection and retrieval of the transfer system

3. The presence of liquid in the transfer system can be seen by either a changing or increasing of LFL between measurements at the sample points and/or a pressure increase within the system while the manifold valves on both sides are closed. Purging/inerting is considered to have been achieved when sampling at the furthest end from the nitrogen injection point measures no more than 2% vol methane.
4. Additional considerations and recommendations for draining, purging and inerting can be found in the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06* and Lessons Learned 7-6: Draining, Inerting and Disconnection Considerations.

7.7.1.2 Disconnection

1. A connection should not be separated unless it is confirmed that there is an inert atmosphere on both sides of it.
2. Disconnection operations differ depending on the means of connection (DD/CC or flange). Operators should be aware of the equipment requirements and the manufacturer's recommendations.
3. Additional considerations and recommendations for disconnection operations can be found in the SGMF publication *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06* and Lessons Learned 7-6: Draining, Inerting and Disconnection Considerations.

***Lessons Learned 7-7:** Draining, Inerting and Disconnection Considerations*

The following list is a collection of considerations and tips that may be used during the draining and inerting of the bunkering line. They are collected here for information and reference for the LNG bunkering organisation and the receiving ship operator.

Draining:

1. **Avoid rapid opening and closing of valves (full bore).** Significant and rapid changes in pressure while liquid is in the bunker system can result in instantaneous natural gas phase transitions (vapour to liquid and vice versa), multiple phase flows, and local high flow velocities. Such conditions could damage the internal hose structure.

2. **Maintain a positive pressure throughout all sections of the bunker system.** A minimum pressure should be maintained until it is evident the bunker system is liquid-free by monitoring the temperature of bunkering lines.
3. **The operator should be aware that, due to the possible arrangements of hoses, liquid may remain and accumulate in the lowest levels.**
4. **The liquid-draining process will depend on the bunker system, the manifold configuration, and whether the receiver manifold is higher, level with, or lower than the supplier manifold.** The delta in head pressures as well as the delta in tank pressures should be taken into consideration when determining the most efficient draining process:
   a. LNG liquid should drain into the supplier tank, the receiver tank or both, depending on the configuration of the bunkering arrangement (for example, whether or not the receiver vessel's manifold is higher than the supplier's, when it will be necessary to consider high and low points in the bunker system)
   b. draining might start with both manifold valves opened to allow the liquid to drain by gravity downwards from the apex point of the bunkering line. In some instances, the practice may be to open both manifold valves to allow liquid to drain, while in other cases, one of the manifold valves can remain shut to facilitate LNG liquid draining with nitrogen pressure
5. **After the liquid has drained by gravity, the remaining liquid in the hose bunker line may be removed by using nitrogen gas flow:**
   a. simultaneously, nitrogen is injected to push the LNG trapped inside the bunker system to either the bunker facility side or the receiving vessel side by raising the nitrogen pressure inside to around 3 bar and releasing the trapped liquid by opening and closing the valve slowly. This operation is repeated three to four times (depending on the quantity of trapped LNG) and done only at the beginning of the draining operation
   b. after three/four nitrogen injections, nitrogen is bled continuously (low flow by keeping the nitrogen valve cracked open) into the bunker system keeping the pressure at 1.0 bar
   c. after about 30 minutes – depending on the bunker system diameter, length and nitrogen flow rate – the gas at the furthest end from the nitrogen injection point is measured for 2%vol methane. When this is reached, nitrogen injection is stopped

6. **A gas (vapour) piston effect can be created by closing the supplier and receiver manifold valves (if there is sufficient liquid left).** This will lead to an increase in the pressure in the bunker system either side of the trapped liquid. Opening one of the valves while keeping the other closed should push some of the liquid out of the bunker system.
7. **Water spraying can be used to warm the exterior of the bunker system to accelerate the natural boil-off rate of the liquid inside, but does not replace the use of nitrogen.**
8. **To check whether there is still liquid in the bunker system, both valves at the two manifolds should be closed and the pressure observed.** This will lead to an increase in the pressure in the bunker system. If the pressure increases quickly, there is still LNG in the line.
9. **If composite hoses are used for the bunkering, it is possible for liquid to initially remain in the composite layers. It will be released slowly back into the hose during purging operations.**

Inerting:

10. **The receiving gas-fuelled vessel's bunkering line (liquid and vapour when in use) should be left in a gas-free condition at the termination of operations before disconnection of the bunker system, unless the consequences of not gas-freeing are evaluated and approved.**

REF: IGF CODE, 2016 EDITION § 8.5.5
Bunkering lines shall be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering pipes shall be free of gas, unless the consequences of not gas freeing are evaluated and approved.

11. **The LNG bunkering organisation and the receiving ship operator should develop procedures and protocols for gas-freeing and inerting the bunkering lines.**
12. **Gas-freeing of the hose bunker system may be avoided provided that the hose bunker system is equipped with a DD/CC with self-sealing quick-release capability.** However, this is subject to:
    a. implications and potential risks of not gas-freeing having been evaluated and approved by both parties and relevant authorities, such as the port administration
    b. agreement by supplier and receiver. Note that not all parties may recognise this as an acceptable practice

c. procedures having been put in place to disconnect the hose safely while it is not gas-free (for example, DD/CC disconnection, maximum allowable pressure in the hose, and so on)
d. procedures having been put in place to handle and manage the hose safely after retrieving it at the bunkering facility, including dummy DD/CC receptacle connection for inerting and procedures to avoid venting to the atmosphere
e. bunkering facilities having the means to monitor and detect gas leakage from the hose bunker system while stored "not gas-free"

Disconnection:

13. To minimise potential leakage, only one bunker line is to be disconnected at a time.
14. To facilitate disconnection, ensure ice build-up is removed using water that drains freely.
15. There should be no or negligible pressure in the bunker system before it is disconnected:
    a. ensure the pressure is released before breaking flange connections
    b. pressure differential can be measured at the bunkering manifold pressure indicator (see Figure 4.2)
    c. if DD/CCs are used, it is possible to leave pressure behind the coupling. This should be checked with the manufacturer of the DD/CC
16. **Operators should be aware that, after disconnection, ambient moisture will rapidly enter the bunker system/hose and condense on the inner surface:**
    a. if a bunker system is not properly dried afterwards, this moisture will eventually end up in the downstream (receiving vessel) piping and may jam valves or block pipelines. For this reason, immediately after disconnecting, close all the open connections using a blind flange
    b. The blind flange must be rated for the design pressure of the bunker system or manifold, to prevent it from breaking if is pressurised accidentally. If it is necessary to open the connection while still cold, a small flow of nitrogen gas may be applied to create an outgoing stream of dry gas that prevents moist air entering the pipe

7.7.2 Equipment retrieval and storage

1. After disconnection, the bunker system should be retrieved and stored:
   a. the retrieval procedure should follow the agreed lifting procedures
   b. before retrieval, surroundings should be checked to confirm that there is a clear path and that lifting line/straps, if used, are properly connected
   c. the storage area should be free of obstacles
2. Operators should be aware of the risk that, at the end of the draining operation, a small quantity of liquid may remain trapped in lower pockets of the bunker system. Note that this small quantity of liquid may not be detectable by monitoring the pressure or by checking the gas content:
   a. this happens very rarely, and experience shows that the quantity of liquid is usually very small. It will evaporate quickly when the bunker system is disconnected
   b. it is good practice to disconnect the bunker system slowly, moving it upwards from the manifold to which it is still connected, taking particular care when flattening the hose low points, which is where any remaining liquid is most likely to be found

7.7.3 Post-bunkering documentation

1. When bunkering operations have been completed, Part E of the IAPH checklist (see Section 3.6) should be completed to document that the operation has been concluded in accordance with the agreed safety procedure.
2. The receiving vessel should receive and sign a bunker delivery note for the fuel delivered. Details of the bunker delivery note are specified in the annex to Part C-1 of the IGF Code.
3. Any lessons learned during the operation should be recorded and shared, in line with the organisation's procedures.

8. Additional Considerations and Recommendations for Bunkering

This chapter provides readers with an additional set of considerations and recommendations addressing specific or unconventional LNG bunkering operations.

The objective is to share an understanding of such operations and ensure that all bunkering stakeholders have considered them during the various stages of LNG bunkering.

8.1 Emergency Shutdown and Disconnection

The bunkering emergency shutdown and disconnection ESD-1 and ESD-2 events are safety-critical functions of the bunkering operation

The emergency shutdown (ESD) system automatically stops the transfer of LNG (ESD-1) and the emergency release system (ERS) allows the physical disconnection of the two systems (ESD-2) via the emergency release collar (ERC).

Note:
Gas-fuelled vessel and the bunkering facility/supplier owners and operators should develop specific procedures for emergency shutdown ESD-1 and disconnection ESD-2 events.

These should include safety instructions on how to manage the ERC disconnection which might happen with the bunker hose, or a section of it, still attached, and the control and management of any rapid pressure increase due to any LNG left in the bunkering line.

Considerations and recommendations:

1. The bunkering ESD emergency shutdown discussed in this publication should not be confused with the "ESD-protected machinery spaces" widely discussed in the IGF Code. While both are shutdown functions in response to an emergency, they act separately and on different equipment and areas.

2. Readers should refer to the SGMF publication *Recommendations for linked emergency shutdown (ESD) arrangements for LNG bunkering – TGN06-05* for a full list of recommended triggers and consequence actions.
3. Bunkering procedure (see Section 3.6) should include step-by-step instructions:
   a. on how the ERS, ERC and fall-arrest system, where employed, operate
   b. on how to troubleshoot ESD alarms and understand the root causes to allow the subsequent clearance of ESD alarms
   c. on how to deal with bunkering ESD-1 events
   d. on how to deal with bunkering ESD-2 events
   e. on how to deal with an ERC separation, including recovery of split ERC and attached hoses, where applicable

***Lessons Learned 8-1:** ESD-1 and ESD-2 Considerations*

1. Both the gas-fuelled vessel and the bunkering facility should have procedures in place to manage the bunker system, and any liquid left inside, in a safe and controlled manner following an emergency shutdown.
2. In an ESD-1 event, the parties are required, as applicable, to:
   a. monitor the pressure in the whole bunkering line
   b. monitor hose stretch and bunker system free movement (as applicable)
   c. identify the cause of the ESD-1 event and release the liquid lock after a full assessment of the cause and of the condition of the bunker transfer system
3. In an ESD-2 event, the parties are required, as applicable, to deal with liquid trapped in their side of the bunker system and have in place a procedure to retrieve hanging hose sections safely and promptly (see Figure 8.1 for a hose bunker system example).
4. As general guidance, emergency procedures for hose retrieval should consider:
   a. the implications of the hose coming into contact with water:
      i. the vessel operator should be aware of any increased vaporisation rate and the resulting rapid pressure build-up in the hose
      ii. the potential impact on the hose of marine operations such as unmooring and vessel manoeuvring

b. the need for special consideration to be given while handling hoses to prevent metal-to-metal contact with the structure of the gas-fuelled vessel and the bunkering facility
c. the importance of minimising exposure of personnel in the immediate area
d. the need for vessels to have arrangements in place and equipment available to recover the hose
e. the need for the hose, once recovered, to be evaluated to check its suitability for future use. The bunker facility should seek guidance from the manufacturer in the evaluation of the hose, which should include: bending radius, tension and pressure experienced during the ESD-2 event

5. When loading arms are used as bunker system, following an ESD-2 and ERC release, the loading arm should retract and park automatically, leaving part of the ERC and connectors attached to the receiving gas-fuelled vessel's manifolds. These should be then retrieved after the ESD-2 emergency has been cleared.

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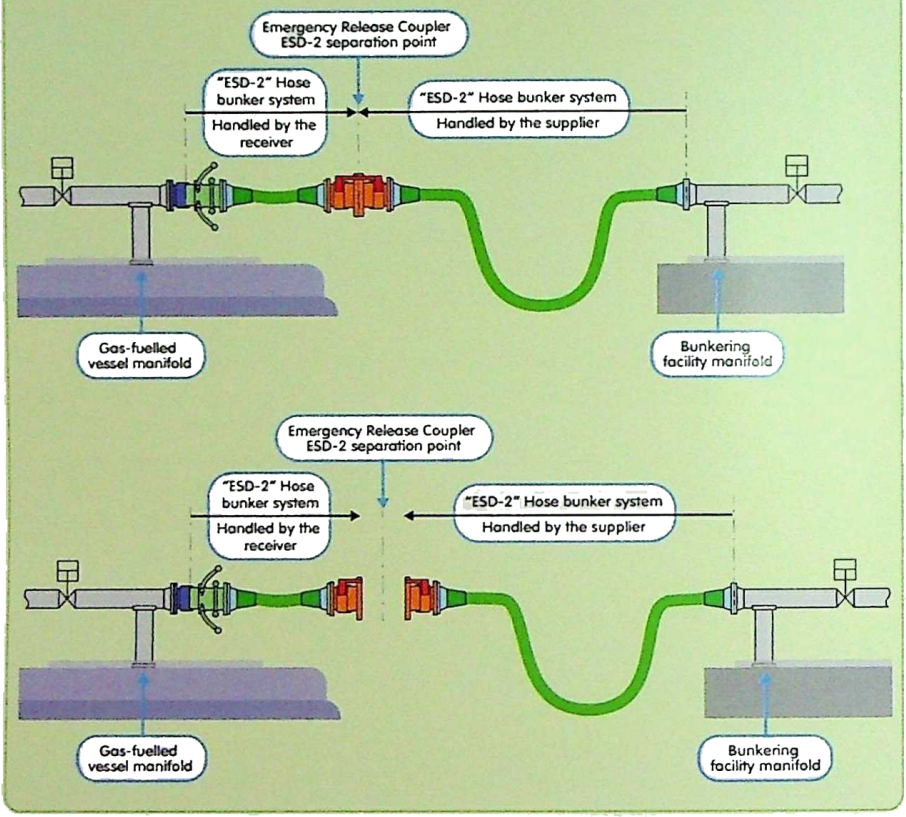
Figure 8.1: Hose-handling procedures after an ESD-2 event



8.2 De-bunkering, Gassing-up and other Special Operations

Non-conventional operations, such as de-bunkering, or non-routine operations such as gassing-up, cool-down and gas-freeing a gas-fuelled ship's tank(s), may be carried out in special circumstances, such as during commissioning or prior to or after maintenance and dry-docking.

While these operations are not referred to as bunkering, there is an underlying similarity across them, in that a transfer of LNG and or natural gas takes place between a supplier and a gas-fuelled vessel.

Considerations and recommendations:

1. Designers should consider unconventional and non-routine operations during the design process. Design considerations should include:
   a. the management of large quantities of boil-off gas that may be produced
   b. the typically long times required for such operations
2. Shipowners and operators should have an approved management plan outlining procedures for unconventional and non-routine operations. This may include:
   a. operations carried out in yards
   b. additional requirements by port authorities/regulators
   c. specific risk-assessment workshops
3. Where applicable, the underlying safety principles and processes set out in this document should be followed.

Note:
Owners, operators, and designers should refer to the SGMF publication FP10-01, Ver 1.0 *Work practices for maintenance, repair and dry dock operations* for additional guidance on unconventional and non-routine operations.

8.3 LNG Bunker Vessel Mooring Considerations

Ship-to-ship bunkering may take place in port or in open water (for example, at anchorage), so safety/operational procedures should be adapted as required by the local conditions and regulations.

Where operations are to be undertaken at anchorage, the safety, security and monitoring zones should take into account any swing on the anchor that may occur during the operation.

When mooring, the bunker vessel should manoeuvre alongside the receiving ship safely. Bunker vessels are to moor alongside in such a way that they may separate and move away quickly in an emergency.

The responsibility for safe mooring and unmooring/departure of the bunker vessel lies with the bunker vessel and should be agreed in advance.

8.3.1 Ship-to-ship bunkering with dynamic positioning or underway

Ship-to-ship bunkering with dynamic positioning (DP) vessels or underway is sometimes discussed as an alternative to the more traditional ship-to-ship LNG bunkering at anchor by mooring the vessels alongside.
These are deemed unconventional operations and there are no current examples of LNG bunkering being conducted in such a way.

Shipowners and operators planning for future LNG bunkering with DP or underway are recommended to follow a risk assessment approach and engage with regulators and/or the port authorities with jurisdiction over the location of bunkering, and/or the operation, to obtain the necessary authorisations.

8.4 Onboard truck-to-ship bunkering

Onboard truck-to-ship bunkering is an unconventional variant of a truck-to-ship operation but is used in some applications, particularly for bunkering fuels to Ro-Ro vessels (see Figure 8.2).

Considerations and recommendations:

1. While the underlying safety principles and processes set out in this document should be followed, case-by-case specific considerations are required. These should include:
   a. how to drive the trailer on and off the ship during normal and emergency situations
   b. the positioning of the trailer on the deck, as well as cargo in the area and SIMOPs
   c. truck PRVs discharge area and safety zones
   d. the additional and temporary presence of the hazardous zone around the trailer
   e. the need for the ESD-2 functionality
   f. area lighting
   g. trailer grounding
   h. containment of connection leaks (Note that water curtains cannot be typically employed and a drip tray that cannot be drained may be required.
2. Trailers are disconnected before ship departure.

3. Bunkering is not allowed at sea
4. LNG trailers and their connecting equipment used on board may be required to comply with the IGF Code, as applicable, in addition to national, regional or international standards.

Figure 8.2: An example of onboard truck-to-ship bunkering (Picture courtesy of BC Ferries and Fortis BC)

8.5 Portable LNG Fuel Tanks

Portable LNG tanks, as discussed in Section 3.1.5, are an alternative method of providing fuel to a vessel.

Portable tank(s) can be replaced with new ones, when empty, or bunkered by a supply facility.

Considerations and recommendations

1. Procedures for bunkering vessels using portable LNG tanks or replacing a portable tank on board should demonstrate a level of safety equivalent to ship-to-ship and ship-to-shore bunkering procedures.

2. The method for safe disconnection of portable tanks will vary depending on the specific design of the system. The general principles remain the same:
   a. all pipe connections are to be isolated at the delivery and receiving ends
   b. the connecting hose(s) should be purged and inerted to below the lower flammable limit to minimise the risk of ignition and minimise the release of natural gas during disconnection
   c. hoses and connections should be securely blanked or otherwise protected to avoid the ingress of moisture and oxygen into the system
3. Disconnection and replacement of tanks should not be done at sea.
4. Portable LNG tanks used as LNG fuel tanks should be designated according to both the International Maritime Dangerous Goods Code (IMDG Code) and the IGF Code.
   a. portable LNG tanks and their connecting equipment used on board should comply with the IGF Code, in addition to national, regional or international standards
   b. additional arrangements should be in place to ensure that the portable tank's PRVs are connected to an IGF Code-compliant vent mast

8.6 Bunkering LNG into Membrane and Low-Pressure Tanks

This section mainly provides an additional set of considerations and recommendations addressing LNG bunkering operations where the receiving vessel containment system is a membrane-type tank. Furthermore, these may be applicable to other types of atmospheric and low-pressure tanks – for example, type B.

Membrane tanks are a well-known and widely used containment system option in the large-scale LNG market. In recent times, this type of tank has made its appearance on LNG-fuelled vessels and has proven to be a viable option to the more traditional type C tanks where large volumes of LNG fuel are required on board.

Membrane systems have a lower design pressure compared with type C tanks. This is typically around 700 mbarg and therefore requires a different approach to vapour- and pressure-management during bunkering operations.

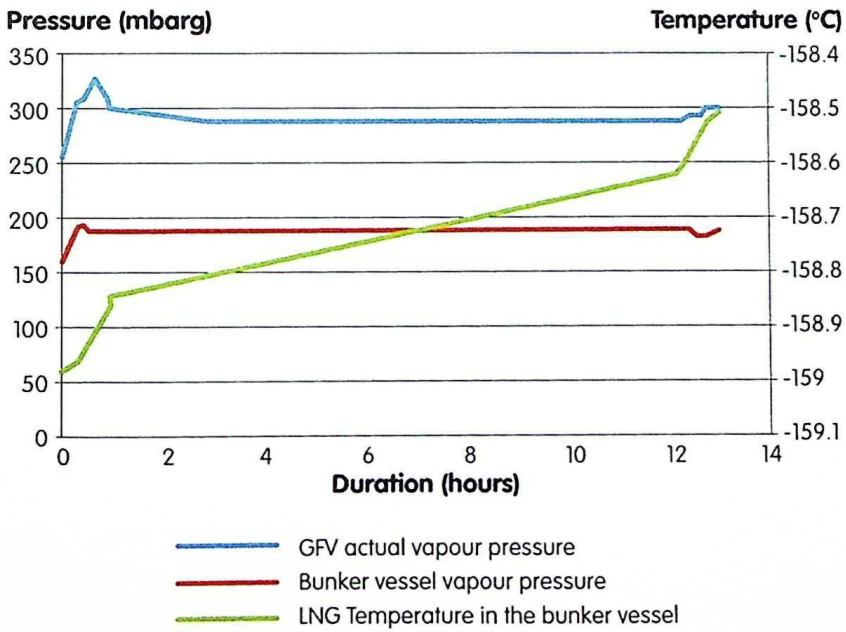
The following represents the collective experience of SGMF's membership regarding a number of LNG bunkering operations to vessels with membrane systems.

The application of any recommendations is left to the skilled design team and operator, who should evaluate which of the following is applicable or not to a specific vessel and, if so, under which circumstances.

Figure 8.3 provides a typical example of the trend of pressure and temperature during a bunkering operation on a membrane tank. Note:

- the increase of pressure at the start of the bunkering operation due to the heat exchanged between the warm LNG already present in the tank and the colder LNG being bunkered
- the final increase of pressure and LNG temperature at the end of the bunkering operation during ramp-down and topping-up of the tank

Figure 8.3: A typical pressure and temperature bunkering diagram for a membrane system tank (Picture courtesy of CMA-CGM)



Considerations and recommendations:

1. Management of vapour generation is the key point of bunkering operations to membrane tanks.
   a. a vapour return line should be deployed between the bunkering facility and the gas-fuelled vessel
   b. the vapour generated during bunkering should be shared between both supplier and receiver. The receiving vessel may use part of vapour as boil-off gas for a hotel load, while the remaining vapour is returned to the supplier to compensate for LNG displacement
   c. the fitting of additional measures for managing vapour should be considered during design of the gas-fuelled vessel and bunkering facility. This may include a gas combustion unit, a reliquefaction plant, a sub-cooling system, or other means
2. Bunkering procedures should be tailored to reduce generation of vapour in the first place:
   a. to reduce vapour return generation, the receiving vessel should arrive with its LNG tank ready to bunker. This means in a cold condition so that less flash vapour is generated due to heat, and with as low a tank pressure as possible to allow a greater operating margin for pressure rise
   b. it is good practice to monitor and agree a maximum control tank pressure not to be exceeded during bunkering. This should be lower than the maximum allowable pressure of the tank. (Good practice is that the maximum operating pressure should not exceed 70% of the relief valve setting.) If it is exceeded, the bunkering flow rate should be immediately reduced, and supplier and receiver should confirm and explain the reasons for the pressure rise
   c. to control vapour generation and pressure rises, reliable and robust communication of transfer process parameters and receiving and supply tank conditions should be in place
   d. the gas-fuelled vessel should also be prepared to manage the increasing nitrogen consumption in the membrane system inter-barrier space, due to thermal shrinkage of the membrane in contact with cold LNG

9. Bunkering Risk Assessment

A number of risk assessment workshops and exercises are recommended to be undertaken during the key stages of bunkering to ensure the operation is executed safely.

Note that this publication discusses only the requirements for the LNG bunkering risk assessment, covering the aspects of the bunkering/fuelling operation of a gas-fuelled vessel.

Additional and complementary risk assessment workshops and exercises should be conducted to cover other aspects and risks related to the handling, storage and use of LNG, and as required by applicable regulations and standards.

In this chapter:

- **Section 9.1 A route for the bunkering risk assessment**
  Presents a suggested route that may be followed in the various stages of developing the LNG bunkering operation, indicating when and why different risk assessment workshops and exercises might be conducted and what the objectives are.
- **Section 9.2 Background knowledge on bunkering risk assessment**
  Provides the reader with basic background knowledge on risk assessment, with a focus on LNG bunkering. However, the specific details of how a risk assessment is conducted and recorded, and mitigations implemented, are not discussed. This section does not set out to provide full and in-depth guidance on risk assessment approaches or methodologies.

This chapter should be read and complemented by further and more specific guidance on the overall risk assessment topic. Readers are recommended to refer to:

- ISO/TS 18683 and ISO20519 for detailed guidance on the use and application of risk assessment
- the SGMF publications *Recommendation of Controlled Zones During LNG Bunkering – FP02-01, Ver 1.0* and *Simultaneous Operations (SIMOPs) during LNG Bunkering – FP08-01, Ver 1.0* for further guidance on safety zone definition and management, and SIMOPs

Note:

1. Risk assessment is an essential discipline to ensure safe LNG bunkering operations. All bunkering stakeholders and parties involved should engage, as applicable, in appropriate risk assessment workshops and exercises
   a. all bunkering stakeholders and parties (see Chapter 3.2) share responsibilities for bunkering operations, requiring their inputs into the risk assessment process and ownership of the outcome actions and the mitigations to be put in place
2. Risk assessment workshops and exercises should be held with a suitable team of multidisciplinary experts from the different stakeholders:
   a. these should include experts on marine operations, port operations, terminal operations, LNG bunkering operations, LNG risks, emergency response, and so on
3. It is recommended that risk assessment workshops and exercises are conducted, and process actions and outcomes recorded, by a suitably trained and competent facilitator:
   a. the facilitator is an independent role, and he/she should aim to ensure that a comprehensive and robust process is followed
   b. when required/appropriate, the facilitator role may be assumed by a third-party organisation, such as a Classification Society

9.1 A Route for the Bunkering Risk Assessment

This publication recommends a route to be followed throughout the key stages of LNG bunkering, during which a number of risk assessments may be undertaken (see Figure 9.1).

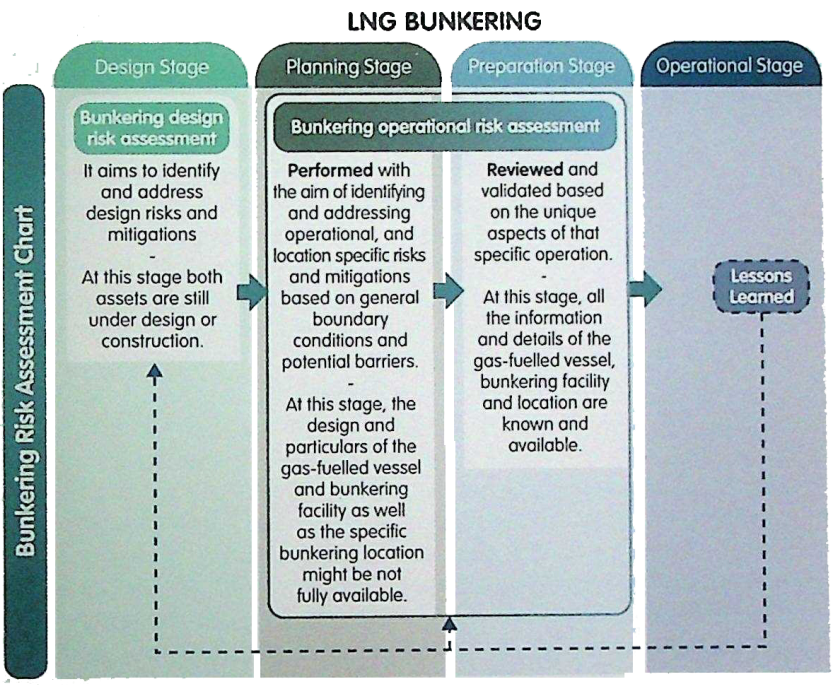


Figure 9.1: Recommended bunkering risk assessment route

The purpose is to lay out, for the different stakeholders, a route where potential risks are identified and addressed from the early stages of the design of a gas-fuelled vessel or bunkering facility, through the planning and preparation of the bunkering operation, to the actual operation – while ensuring that any lessons learned are fed back into the risk assessment process for future operations.

The overall objectives are to identify and address:

- risks concerning where and when bunkering is allowed
- risks during and immediately before and after the actual bunkering operation

Note:

1. Note that while this publication suggests a route to the bunkering risk assessment and introduces the concept of design and operational risk assessments, the ultimate decisions on what type of risk assessment should be conducted, the acceptable risk criteria to use, and when a risk assessment is required, depend on the competent authority with jurisdiction over the bunkering area, location and operation. Statutory requirements for risk assessment set by the "authority with jurisdiction" must take precedence over the recommendations provided in this document.
2. Depending on the bunkering area or location, the competent authority might be the national or local regulator and/or the port authority (see Section 3.2).
3. Organisations intending to supply or receive LNG as fuel, in a specific area or location, are responsible for checking and confirming with the local authorities which is the competent authority with jurisdiction, and of identifying the risk assessment requirements that need to be met to obtain approval or licensing for bunkering. Note that statutory requirements for risk assessment are likely to vary location by location and, in some cases, even among ports under the same national regulator.
4. The competent authority is responsible for informing the parties interested in conducting LNG bunkering about statutory requirements for risk assessment, including risk criteria to be met and, if applicable, any required process or methodology.

9.1.1 Bunkering design and operational risk assessment

The key recommended steps for bunkering risk assessment are:

- **Bunkering design risk assessment**
  Performed during the design stage, it aims to identify and address design risks and mitigations (see Section 4.11).
- **Bunkering operational risk assessment**
  Performed and subsequently reviewed during the planning and preparation stages, it aims to identify and address operational and location-specific risks and mitigations (see Sections 5.6 and 6.5).
- **Lessons learned**
  It is good practice for lessons learned to be collected and the relevant information fed back to the design or operational risk assessments, as applicable.

Considerations and recommendations

General

1. The competent authority with jurisdiction over the location of bunkering and/or the operation may set out location-specific risk assessment requirements which may specify the type of risk assessment to be carried out and the applicable risk criteria
2. owners and operators should engage with local regulators and port authorities during the early planning stage to validate their risk assessment approach.
3. Risk assessment documentation, including reports and recommendations, should be collected and maintained within the LNGBMP (see Section 3.6).
4. Risk assessments should be regularly reviewed and updated if required.

Bunkering design risk assessment

1. A bunkering design risk assessment is a recommended step, whenever possible, to identify and address risks at an early stage.
2. A bunkering design risk assessment should aim to:
   a. identify any risks to people, assets or the environment which are required to be eliminated ("engineered/designed out", where

possible) or mitigated through design of the gas-fuelled vessel, the bunkering facility and/or the bunkering equipment
   b. assess whether the design is fit for purpose, is safe to operate and maintain, and considers the requirements of the IGF Code or other statutory codes, if applicable, and Class and/or owner requirements
3. A bunkering design risk assessment should consider different bunkering supply scenarios and configurations:
   a. gas-fuelled vessels may consider bunkering operations from bunker vessels and shore facilities, such as terminal or road trailers
   b. bunkering facilities may consider the bunkering of different type of vessels, from cargo ships to passenger vessels
   c. both may consider different potential SIMOPs as applicable to their vessel or installation
4. A port or location may have conducted a series of risk assessments to create a bunker map where bunkering is generally allowed by the competent authority. A new bunkering facility must demonstrate that its risks lie within the scope and magnitude of bunker map risk assessments. If the risk parameters are exceeded, the new facility will need to conduct a full risk assessment for consideration by the competent authority. Similarly if the proposed location is at a location outside of the current bunker map a full risk assessment needs to be performed to allow the competent authority to consider approval and expansion of the bunker map.

Bunkering operational risk assessment

1. A bunkering operational risk assessment should be always be performed by the interested stakeholders before a new bunkering operation is allowed. This is often a requirement set by the authority with jurisdiction over the bunkering location, area and/or operation.
2. Any outcome from an earlier bunkering design risk assessment (if performed) should be made available and reviewed as applicable to the specific operation and location. It can then be used as a basis for the bunkering operational risk assessment.
3. A bunkering operational risk assessment should aim to:
   a. identify any location-specific risks, such as terminal or surrounding industry/people hazards, considering the time that the bunkering is due to take place
   b. provide insight and information to determine the leak scenarios used to set the required safety zone, and the monitoring and security area

around the bunkering operation
   c. assess and demonstrate which SIMultaneous OPerations (SIMOPs) can be carried out at the same time as bunkering
   d. demonstrate that the design, operational procedures, management system and training of the installation have eliminated risks to people and the environment, where possible, or mitigated them, if necessary
4. The bunkering operational risk assessment should consider, but not be limited to, the following:
   a. the design and layout of the gas-fuelled vessel, bunkering facility and bunker transfer system
   b. the specific bunkering procedures and operations
   c. hazardous zones and safety zones
   d. SIMOPs
   e. the local area layout, including:
      i. other port or area operations
      ii. neighbouring facilities and public location and impact
      iii. traffic and traffic management (marine and shore)
   f. the emergency response plan
   g. personnel training and readiness (supplier, receiver, port, terminal and emergency services)
5. Consideration should be given to carrying out the bunkering operational risk assessment during the planning stage of bunkering and reviewing and confirming its validity during the preparation stage. This ensures that any assumptions made during the original assessment are still applicable and that no new risks have been introduced.
   a. A new bunkering operational risk assessment will be required if:
      i a new risk, not previously considered, is identified
      ii. the bunkering location is moved under a different jurisdiction (a risk assessment performed and accepted by a local authority may be accepted or partially accepted by other regulators and port authorities after a review of its applicability – but this should not be deemed automatic and such an approach should be discussed and agreed by all relevant stakeholders)
      iii. there is a change in the assumptions made to demonstrate the acceptability of the original bunkering operational risk assessment (this change may be a different bunkering supply scenario, a different type of vessel to be bunkered, different or new stakeholders now involved, or a lesson learned from other operations/industry that needs to be considered)

iv. the bunkering equipment and/or procedures have been modified from those assessed by the original bunkering operational risk assessment
v. the bunkering operation is outside the terms of the bunker licence

b. it may not be necessary to perform a new bunkering operational risk assessment before the bunkering operation, if during the risk assessment review in the preparation stage:
i. all parties agree that the risk profile is the same, and
ii. there are no new risks which have not been considered in the original bunkering operational risk assessment, and
iii. any variation has already been covered in the original bunkering operational risk assessment and the terms of the bunker licence

6. Consideration should be given to broadening the scope of the bunkering operational risk assessment beyond the first accepted bunkering configuration/supply scenario. This should aim to provide wider coverage in case future operations differ from initial assumptions. The following may be considered, subject to their applicability:
a. a gas-fuelled vessel should consider being bunkered:
i. by a bunker vessel, a shore facility and a mobile supply
ii. with low and high transfer rates
iii. with different bunkering systems, typically hoses or loading arms
iv. in different environmental and sea conditions
v. in different locations within the same port/area
b. bunkering facilities should consider bunkering:
i. different types and sizes of vessels (passenger, cargo and so on)
ii. different flow rate and volumes
iii. different environmental and sea conditions
iv. using different types of bunkering systems
v. in different locations within the same port/area
c. all parties should consider how operations and risks are impacted by:
i. bunkering operations conducted by different LNG bunkering organisations or to different receiving ship operators
ii. a larger variety of SIMOPs
d. include in the risk assessment workshop and exercise:
i. future potential stakeholders (this might not be the immediate intended supplier, receiver or jurisdictions but may be expected to be in the future)
ii. additional and independent experts to bring wider experience and inputs

9.2 Background Knowledge on Bunkering Risk Assessment

This chapter provides the reader with basic background knowledge on risk assessment techniques, with a focus on LNG bunkering operations.

The intent is to provide those not typically familiar with risk assessment processes, but required to participate in risk assessment workshops or exercises as a subject matter expert, with a sufficient level of knowledge so that they are able to follow the process in a more involved way.

Stakeholders involved in risk assessment workshops and exercises who are interested in deepening their knowledge may wish to seek in-depth guidance from specific publications (see Chapter 10).

9.2.1 Scope

Whether during a design or operational risk assessment, and whatever methodology is used (see Section 9.2.3), an LNG bunkering risk assessment should cover, as a minimum:

1. How the bunkering operation could potentially cause harm – that is, systematic identification of potential equipment/vessel incidents that could result in fatality, injury or damage to the environment.
2. The potential severity of harm – that is, the worst-case consequences of the incidents identified in point (1), in terms of number of fatalities, extent of injuries, and environmental damage caused
3. The likelihood of harm.
4. A measure of risk, where risk is a combination of points (2) and (3).
5. How the functional requirements are to be met and how barriers and mitigations are defined and implemented.

In addition, the risk assessment should:

6. Help to identify the scenarios to be used to determine safety and controlled zones.
7. As a minimum, consider SIMOPs within the safety zone.

Regardless of the approach used, the risk assessment should be carried out by a team of suitably qualified and experienced individuals with collective

knowledge of, and expertise in: risk assessment application; engineering design; emergency response; and, specifically, LNG bunkering operations.

9.2.2 Risk criteria

As the scope of the bunkering risk assessment is understood, the stakeholders should define and agree the appropriate risk criteria.

Considerations and recommendations

1. Different stakeholders will have different risk criteria. Risk criteria also vary based on the bunkering location or area and the competent authority with jurisdiction. Risk criteria include the risk tolerability on residual risk (after all controls and mitigations are in place) where the concept of "As Low As Reasonably Practicable" (ALARP) – which has spread internationally – may be used. Other approaches defined by individual and societal risk numbers are adopted by some jurisdictions.

Note:
The "As Low As Reasonably Practicable" (ALARP) concept requires that *"risks are demonstrated to be ALARP and that demonstration has been accepted and verified"*. The ALARP demonstration for individual risks is essentially a simple concept which can be satisfied by the **Operator** answering the following fundamental questions:

- What more can I do to reduce the risks?
- Why have I not done it?

Reference/source: UK Health and Safety Executive's Guidance on ALARP Decisions in COMAH (Control of Major Accidental Hazards).

2. Minimum risk criteria should be set by the competent authority with jurisdiction over the location of bunkering and the operation (typically the national regulator):
   a. the shipowner, bunkering organisation and so on may have their own standards – but these are only appropriate if they are more stringent than the minimum criteria
   b. although criteria from different sources may appear similar, it is important to note that there are no universally agreed risk criteria: there

are differences between governments, regulators and organisations

3. Guidance on the selection of appropriate criteria should be sought from, and may be given by, the regulator and/or authority with jurisdiction over the location of bunkering and the operation. In addition, many industry organisations, such as international oil and gas companies, have specific risk criteria that are extensively used to demonstrate safe onshore and offshore operations to governments and regulators.

9.2.3 Risk assessment methodologies

The methodology of risk assessment undertaken is driven by a number of factors, such as: type and number of persons potentially at risk, the complexity of the bunkering operation, and mainly by the requirements of the regulator and/or port authority with jurisdiction over the location of bunkering and the operation.

Typically, a risk assessment follows one of the three methodologies:

- Qualitative Risk Assessment (QualRA), in which analysis is undertaken to categorise the likelihood of events and their consequences or impact, using judgements to provide a combined assessment in the form of a grading/ranking that can be compared against pre-defined criteria.
- Quantitative Consequence Assessment (QCA) – for example, specific consequence models or computational fluid dynamics analysis, where the predicted outcome of selected events in terms of magnitude and distance is analysed to determine the extent to which casualties and damage may occur.
- Quantitative Risk Assessment (QRA), in which a systematic numerical analysis is undertaken for a range of event likelihoods and their consequences or impact to provide a combined assessment in the form of a number, rate or contour that can be compared against pre-defined criteria.

Considerations and recommendations

1. A universal risk assessment methodology is not defined, with different approaches possible. The choice of the assessment methodology should therefore be considered against the scope of the bunkering operation to be assessed. In some circumstances, a combined approach may be the best option.

2. A qualitative risk assessment (QualRA) tends to be more subjective than other methodologies but quicker and easier to implement, without the need to process large amounts of data. This might be considered:
   a. as an initial evaluation, prior to carrying out a QRA or QCA
   b. when there are no significant deviations from the typical bunkering supply scenarios (see Section 3.1) and bunkering key stages (see Section 3.4), then the qualitative approach may be sufficient to meet the objectives of assessment and to demonstrate that the overall risk acceptance criteria are met and are ALARP
   c. if it is accepted by the authority with jurisdiction over the location of bunkering and the operation
3. A quantitative consequence assessment (QCA) uses expert judgement to identify the events to be analysed and numerical models to estimate the potential consequences of those events:
   a. in a QCA the risk has been defined by others, mostly the competent authorities, through a series of "design incidents" which the numerical models then show are complied with – for example, LFL must not be beyond a certain distance from the manifold
   b. a QCA may be considered when the use of a QRA is inadequate to determine the risks because:
      i. it predicts safety distances which need reduction by more detailed analysis of specific release behaviours
      ii. spatial factors (such as building layouts) and meteorological factors (primarily wind) cannot be considered in suitable depth by a QRA
4. A quantitative risk assessment uses verifiable data to analyse the effects of risk. However, this relies on accurate statistical data to produce a reliable assessment, which may not always be available and can take a long time to process.
5. QCA and QRA may be considered:
   a. as a supplement to the QualRA
   b. when the bunkering operations are undertaken in sensitive locations (such as areas in close proximity to population centres or critical infrastructure)
   c. to support a reduced safety zone and/or security zone for bunkering
   d. to appraise design options and mitigation alternatives
   e. to appraise bunkering supply scenarios deviating from the standard configurations discussed in Section 3.1
   f. if required by the authority with jurisdiction over the location of bunkering and the operation

9.2.4 Typical bunkering risk assessment approach

This section presents a typical LNG bunkering risk assessment approach that may be tailored to a specific bunkering scenario and the requirements of particular stakeholders.

The scale of risk assessment required for a bunkering process will depend on the supply scenario and the equipment used.

More detailed levels of risk assessment may potentially be required where novel procedures and/or equipment are employed. In such cases, QRA assessment may be impacted by the lack of probability data associated with unproven novel technology.

Risk assessment activities are generally broken into two main parts:

- firstly, a high-level HAZID defines the possible scenarios
- secondly, a HAZOP looks at more detailed scenarios and provides mitigations for them
- a further SIMOPs risk assessment may also be carried out, where needed

These activities should be conducted with professional guidance. The chairperson should be independent of all stakeholders to ensure an appropriately detailed and effective outcome.

Where designs or operational procedures are modified after risk assessments have been completed, the risk assessments should be revised. A change management process should be used to identify and document these changes, which should be included in the LNGBMP.

HAZID and HAZOP processes will generate a list of recommendations and an action plan. The action plan will address each recommendation and provide a means for tracking the hazards for assessment and implementation.

The whole process should be formally documented and access to the document controlled, to show due process in closing out actions and mitigations.

Actions need to be closed out before any bunkering takes place.

9.2.4.1 HAZard IDentification (HAZID)

The HAZID process should provide sufficient detail for a designer/operator to fully understand the nature of each hazard and to identify the controls necessary for its management. The outcomes of the HAZID should also include recommendations for additional safeguards and analysis and in some cases risk rankings.

Considerations and recommendations

1. HAZIDs may be reported unmitigated and mitigated to demonstrate the risk reductions achieved, and the impact should barriers fail.
2. To facilitate the HAZID process, the bunkering operation may be divided into smaller steps, each of which is then addressed systematically.
3. The following list may be used to structure or prepare the HAZID exercise for LNG bunkering:
   - preparation (compatibility, testing, mooring)
   - connection
   - inerting of relevant pipe sections
   - cooling down
   - transfer start
   - transfer at nominal flow
   - transfer stop, including topping-up
   - draining and purging
   - inerting
   - disconnection
   - commissioning
   - security
   - local factors (such as weather)
   - generic and port-specific issues

   (Note: The nodes above should define the extent of the system being analysed. They should be considered for all the operations that will take place.)
4. To guide and help the HAZID workshop process, the following guidewords may be used:
   - leakage
   - rupture
   - corrosion
   - impact
   - fire/explosion

- structural integrity
- mechanical failure
- control/electrical failure
- human error
- manufacturing defects
- material selection
- flange or connector failure
- BOG management
- ESD valves control failure
- ERC failure
- loss of containment (piping, valves)
- cryogenic leaks (minor, major)
- hose damage
- major structural damage
- gas leak
- gas dispersion
- gas in air intake
- cooling down operation wrong
- excessive transfer rate
- hydraulic power unit failure
- communication failure
- blackout
- relative motion of vessels
- SIMOPs
- vent unexpectedly not closing
- harsh weather

9.2.4.2 HAZard and OPerability study (HAZOP)

The HAZOP study is a structured and methodical examination of a planned process or operation to identify causes and consequences from a deviation, to ensure that the equipment will perform in line with the design intent.

It aims to identify necessary design measures or changes to prevent failures, incidents and mis-operation, and to mitigate subsequent consequences. Guidewords are used in combination with process conditions to systematically consider all credible deviations from normal conditions.

Considerations and recommendations

1. The HAZOP should be realised with a focus on the LNG bunkering, the transfer of fuel to the receiving ship. The operational modes for the receiving ship to be considered are:
   a. start-up
   b. normal operations
   c. normal shutdown
   d. emergency shutdown
2. A HAZOP divides the process up into nodes:
   a. each node is then examined by a series of guidewords – for example, low flow, high flow, no flow and reverse flow – which cover the normal operational scenarios, including start-up and shutdown
   b. it should be done at P&ID level, so typical nodes would be:
      i. storage tank
      ii. fuel transfer system
      iii. vapour return system
      iv. fuel supply to consumers
      v. utility system operations to support operations
      vi. emergency supporting systems (vent)
3. A HAZOP looks at how the existing system responds to the various failure scenarios and adds mitigations or actions to the eventualities that have been identified.
4. All process operations, equipment and their reactions need to be considered, as appropriate, for the node under review. The following is an example and not a definitive list:
   - joining together of the emergency shutdown systems of the bunkering facility, receiving ship and transfer system
   - emergency procedures in the event of abnormal operations
   - leakage from hoses
   - overpressure of the containment system
   - emergency unmooring
   - emergency venting of LNG or vapour
   - additional protection for the ship's hull in case of fuel leakage
   - emergency shutdown and quick-release protocol
   - requirements for outside assistance such as tugs
   - loss of power
   - connection
   - inerting of relevant pipe sections

- cooling down
- transfer start
- transfer at nominal flow
- transfer stop including topping-up
- draining
- inerting
- disconnection
- fatigue, stress and human error

5. It is recommended that emergency disconnection at the receiving ship's manifold should be addressed by the bunkering operation's risk assessment in order for any potential impact of the system within the receiving ship's bunker station lay-out to be identified and additional mitigation or support utilities to be incorporated, as appropriate.

9.2.4.3 Risk assessment for SIMultaneous OPerations (SIMOPs)

Where it is proposed to carry out bunkering operations concurrently with other operations that may impact or be impacted by the bunkering, then a further risk assessment should be carried out to demonstrate that the required level of safety can be maintained.

Permission is required from the relevant authority before any simultaneous operations are carried out. SIMOPs are not just about the operations of the ship undergoing the bunkering. Port operations and other adjacent activities also need consideration.

The risk level for each SIMOP is to be at an acceptable level (which must meet the same risk tolerance for operations with no SIMOPs, as defined by the competent authority), and all parties involved should be in agreement.

The following list gives examples of where risk assessment for simultaneous operations should be considered:

- cargo handling
- ballasting operations
- passenger embarking/disembarking
- vehicles embarking/disembarking
- dangerous goods loading/unloading
- loading or unloading of any other goods (such as stores and provisions)
- chemical products handling, including toxic cargoes

- the handling of other low-flashpoint products
- bunkering of fuels other than LNG
- any activities external to the bunker transfer and receiving ship operations that may pose a potential hazard during the bunkering operation. Typically this could be activity on the quayside
- any activity which distracts the bunkering crew from performing its tasks effectively
- maintenance and testing of equipment and systems, including software
- any hot work or activity that could create sparks
- any simultaneous shipboard operations that may affect the stable operating condition of the receiving ship. In particular, any testing activity of power, auto ballast or fire systems, for example, are not to be carried out during the LNG bunkering operations unless they have been subject to a risk assessment

The risk assessment should take into account, as a minimum:

- the size of the bunkering safety zone
- the size of any safety zone introduced by the simultaneous operation and how this interacts with the bunkering safety zone
- failure/impact scenarios
- access and escape/evacuation routes
- the transfer scenario (ship-to-ship, truck-to-ship or shore-to-ship)
- the largest credible spill
- the transfer flow rate
- the type of cargo operation
- safeguards to control passenger/cargo movements
- dropped objects
- vent mast positions, air intakes and hazardous cargo handling or restrictions

10. References and Further Reading

The following standards and guidelines are referred to in this document:

Note:
Every effort has been made by the SGMF to avoid discrepancies between the recommendations in this publication and the statutory requirements in international standards and class rules. If discrepancies arise, the statutory requirements must take precedence.

IMO codes

- *IGF Code. International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels*
- *IGC Code: International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*
- *ISM Code: The International Safety Management Code*

International standards

- *ISO 20519:2017 Ships and Marine Technology – Specification for Bunkering of Liquefied Natural Gas-Fuelled Vessels*
- *ISO/TS 18683:2015 – Minimum Requirements on Design & Operations for Safe LNG Bunkering (Seagoing & Inland Navigation Vessels)*

SGMF industry guidelines

- *Bunkering of ships with Liquefied Natural Gas (LNG) competency and assessment guidelines – FP04-02*
- *Simultaneous Operations (SIMOPs) during LNG Bunkering – FP08-01, Ver 1.0*
- *Recommendation of Controlled Zones During LNG Bunkering – FP02-01, Ver 1.0*
- *BASiL : automated Bunkering Area Safety Information for LNG model*
- *Contractual Guidelines – Quantity and Quality – FP05-01, Ver 1.0*
- *Manifold Arrangements for Gas-Fuelled Vessels – TGN06-04, Ver 1.0*
- *Bunker Station Location: Considerations and Recommendations – TGN06-07, Ver 1.0*
- *Gas-Fuelled Vessel LNG Bunker Station Manifolds Arrangement Information Form – Form GFV-A*

- *LNG bunkering with hose bunker systems: considerations and recommendations – TGN06-06*
- *Recommendations for linked emergency shutdown (ESD) arrangements for LNG bunkering – TGN06-05*
- *Work practices for maintenance, repair and dry dock operations – FP10-01, Ver 1.0*

Other industry guidelines

- European Maritime Safety Agency (EMSA): *Guidance on LNG Bunkering to Port Authorities and Administrations*
- IACS Rec. No. 142 "LNG Bunkering Guidelines" (June 2016)

Appendix A: LNGBMP Documentation Content and Recommendations

The LNGBMP is a key document package to support the supplier and receiver in the preparation for their bunkering operation.

It is important for other stakeholders such as the competent authority (e.g port authorities or regulators) to check that all the necessary safety steps have been taken before bunkering licence authorisations are granted

The following recommendations present a balanced approach to creating an effective LNGBMP

1. The LNGBMP is a package/collection of documents
   a. The documents listed in Table A.1 should be available on the gas-fuelled vessel and the bunkering facility, but it is not necessary to assemble all the documents in a single folder or binder.
   b. Some documents may be available in other locations, as per point 2.
2. As far as practical, documents should not be duplicated or copied across different locations – for example, between the safety management systems (SMSs) and the LNGBMP.
   a. Wherever possible and practical, refer to documents held in the SMS to avoid duplication in the LNGBMP
3. As the LNGBMP is a package/collection of documents, it does not typically require third-party approval (for example, by Class). However, some of the individual documents contained in the LNGBMP may require such approvals – for example, the design package documents.
4. The documents listed in Table A.1 should be exchanged between supplier and receiver at various points in the planning and preparation stages. However, only a limited number are required during the operational stage.

The following table A.1 shows in further detail the typical documentation structure and breakdown of an LNGBMP. This might vary depending on the local competent authority.

Table A.1: LNGBMP break-down

LNGBMP breakdown			
Document	**Objective/Content**	**Notes and remarks**	
Design package	Owners and operators of bunkering facilities and gas-fuelled vessels should compile the design package containing the baseline information of their systems and equipment. This might include, as applicable: • General arrangement and particulars • LNG system description and P&ID • Testing procedures and certificates • ERS and ERC system description and P&ID • Hazardous area drawings • ESD system description and cause effect matrix • Bunker system description/ handling and P&ID • Bunker station arrangement and layout • Safety systems description • Lifting gear description and certificates	Compiled during the design and planning stages by the bunkering facility and gas-fuelled vessel. Reviewed and combined by the two parties* during the planning and preparation stages.	Document independently prepared by the supplier and the receiver. Typically found in the SMS. Made available to the other parties for review and consultation.

* The term 'two parties' refers to the owners/operators of the bunkering facility and the gas-fuelled vessel.

LNGBMP breakdown			
Document	**Objective/Content**	**Notes and remarks**	
Emergency response plan	An emergency response plan should be prepared to address potential hazards, such as cryogenic hazards, gas detection alarms, potential cold burn injuries to personnel, and firefighting techniques for controlling, mitigating, and extinguishing a gas cloud fire, jet fire and/or an LNG pool fire. Owners and operators of bunkering facilities and gas-fuelled vessels should prepare their respective response plans during the design stage of their installations and as part of their own safety management systems. During the planning and preparation stages of LNG bunkering, the two plans should be reviewed as part of the risk assessment for the operation, ensuring that the specific bunkering supply scenario and location emergency situations identified are covered.	Prepared during the design stage by the bunkering facility and gas-fuelled vessel. Reviewed by the two parties and local authorities during the planning and preparation stages.	Document independently prepared by the supplier and the receiver. Typically found in the SMS. Made available to the other parties for review and consultation.
Training and drills certificates	Owners and operators should include in the LNGBMP the training and drills certificates and records for everyone involved in bunkering operations All the key LNG bunkering stakeholders are responsible for training personnel Such training needs to be maintained and regularly reviewed	Compiled during the planning and preparation stages by all relevant stakeholders. All relevant stakeholders are responsible for the training and drill activities for all personnel involved.	Document independently prepared by the supplier and the receiver. Typically found in the SMS Made available to the other parties for review and consultation.

LNGBMP breakdown			
Document	**Objective/Content**	**Notes and remarks**	
Safety zones and SIMOPs assessments	Safety zone and SIMOPS assessments are critical activities that the different stakeholders are required to consider as part of the safety risk assessment plan for LNG bunkering operations. It is recommended that safety zone and SIMOPs assessments are carried out by bunkering facilities and gas-fuelled vessels during the design stage to ensure that the key design considerations are taken into account. Jointly conducted safety zone and SIMOPs assessments should be performed during the planning stage and further reviewed/ validated as part of the preparation stage before any LNG bunkering operation is carried out.	Developed by the two parties and local authorities during the planning and preparation stages. The bunkering facility and gas-fuelled vessel may independently perform early general studies in the design stage.	Document typically developed with or in agreement between the supplier and the receiver. This document, or part of it, is developed specifically for a bunkering operation or bunkering supply scenario.
Bunkering procedure • Step by step procedures • Bunkering safety instructions • Operational roles • Communication plan • Mooring plan • Bunkering checklist	The bunkering facility and gas-fuelled vessel should prepare their bunkering procedure during the design and planning stages of LNG bunkering, taking into consideration their specific requirements and the recommendations provided in this publication (see Chapter 7). During the planning and preparation stages of bunkering, the supplier's and receiver's standard bunkering procedures should be reviewed and merged as required and as part of the risk assessment for the operation, ensuring all specific requirements are identified and covered, and building a common understanding of the operation.	Prepared during the design and planning stages by the bunkering facility and the gas-fuelled vessel. Reviewed and merged by the two parties and local authorities during the planning and preparation stages. Used by the two parties during the operational stage.	Document typically developed with or in agreement between the supplier and the receiver. This document, or part of it, is developed specifically for a bunkering operation or bunkering supply scenario.

LNGBMP breakdown			
Document	Objective/Content	Notes and remarks	
Quality and quantity agreement and bunkering delivery note (BDN)	The LNG Bunker Management Plan should include an agreement for the quality and quantity of LNG to be bunkered. For further guidance please refer to the SGMF publication FP05-01, Ver1 0 *Contractual Guidelines – Quantity and Quality*	Developed by the two parties during the planning and preparation stages. Used by the two parties at the termination of the operational stage.	Document typically developed with, or in agreement between, the supplier and the receiver. This document, or part of it, is developed specifically for a bunkering operation or bunkering supply scenario.
Compatibility assessment checklist or report	A compatibility assessment checklist/report should be part of the LNGBMP developed and completed by the supplier and receiver during the planning and preparation stages (see section 3.6.3)	Developed by the two parties during the planning and preparation stages. The bunkering facility and gas-fuelled vessel may independently perform early general studies in the design stage.	Document typically developed with, or in agreement between, the supplier and the receiver. This document, or part of it, is developed specifically for a bunkering operation or bunkering supply scenario.